ISBN 0-7729-0077-4

MINISTRY OF THE ENVIRONMENT

RESEARCH PROGRAM ABSTRACTS

1985 - 86

External Research Projects

POLICY & PLANNING BRANCH

Research Coordination Office

November 1985

Ministry of the Environment

Ontario

The Honourable
Jim Bradley
Minister

Rod McLeod
Deputy Minister

86-03287/

ISBN 0-7729-0977-6

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Goal Statement

"To achieve and maintain a quality of the environment - including air, water and land - that will protect human health and the ecosystem and will contribute to the well- being of the people of Ontario."

DISCLAIMER

The views and ideas expressed in these abstracts are those of the authors and do not necessarily reflect the views and policies of the Ministry of the Environment, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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INTRODUCTION

Scientific research provides the foundation for the solution of environmental problems and for providing state-of-the-art information which is necessary for enforcement and decision-making purposes. The Ministry of the Environment has developed a Research Planning Process which enables the identification of Ministry-wide research needs and priorities, and allows for effective channeling of funds to researchers in universities and consulting firms.

This collection of abstracts provides an overview of currently funded Ministry projects on air pollution, water and wastewater studies, liquid and solid waste research, environmental and health effects of hazardous contaminants, as well as analytical methods, and instrument development.

Further details on any of these projects can be obtained from the Principal Investigator or from the Research Co-ordination Office, telephone (416) 965-5788.

Financial Information

The Environmental Research Program has gained considerable success, and results of completed projects are being applied to the solution of related environmental problems. As a result, the Program has received the support of MOE Management, both administratively and financially. This support is demonstrated by the increase of research funds to a total of $3.2 million in fiscal 1985/86. The cost breakdown of current MOE external research projects is indicated in the following table.

EXTERNAL RESEARCH EXPENDITURE IN 1985-86

	Cost in 1985-86 $ 000s
Ongoing Projects	1,785.1
New Projects	1,404.0
Total	3,189.1

PART ONE

AIR QUALITY RESEARCH

BIOLOGICAL AND CHEMICAL TESTING OF COKE OVEN EMISSIONS

G. Thomas, J. Craigmile, B. Das and A. Horton
Ontario Research Foundation

Key words: PAH, Coke Oven Emissions, Air Pollution, Mutagenicity, Organic Analysis.

ABSTRACT

Ambient air studies in Ontario and elsewhere have shown that polycyclic aromatic hyrdocarbons (PAH) are present in urban and rural air. In some areas coke ovens are a significant contributor to the ambient PAH concentrations, but it is difficult to assess the degree of hazard this poses to the populations in surrounding areas.

This study relates to coke oven emissions, especially with respect to the mutagenicity and chemical nature of solvent extractable fractions of collected particulate material.

Representative HiVol and LoVol samples of coke oven emissions have been collected. Samples were taken directly from the coke oven through a hole drilled in a lid, every hour throughout a complete coking cycle. Simultaneously, samples were collected from on top of the coke oven. The HiVol sample filters were backed up by polyurethane (PUF) foam plugs.

LoVol filters were extracted with benzene. These data provided the benzene soluble fraction of total particulate matter (BSFTPM) to be used as markers to compare with existing occupational data. HiVol filters and PUF plugs were extracted with dichloromethane (DCM). The decision to use DCM was made after suitable experimentation (bioassay and chemical) with separate benzene and DCM extracts.

Organic soluble fractions from selected Lid and Top Side HiVol samples were used in two-tiered short-term mutagenicity assays, namely, a bacterial test (Ames) and a tissue culture test (SCE-CHO). Concurrent chemical analysis was performed on portions of the samples used for the biological assays. In some instances, limited fractionation of the samples prior to chemical analysis was performed.

The sampling and testing protocols were performed at three coke oven locations in Ontario. The results of the biological assays and the concurrent chemical analyses for the selected soluble organic fractions of the HiVol samples will be discussed.

EXPERIMENTALLY DETERMINED MUTATION RATES IN LUNG AND BRONCHIAL EPITHELIA AS A PRIMARY AIR POLLUTION STANDARD

J.A. Heddle, K. Jain, H. Kaul, and D.B. Couch
Department of Biology, York University

Key words: Mutagenicity Assays, Air Pollution, Mutation Rates, Health Effects, Inhalable Particulates, Exposure.

ABSTRACT

One of the health hazards arising from the inhalation of polluted air is cancer of the lung and trachea. Since epidemiological studies of exposed populations and animal cancer bioassays are too cumbersome to be used as primary standards for air pollution, a more practical standard must be used. This project is dedicated to developing a more relevant biological standard than raw particle counts or benzpyrene determinations. The central role played by mutation in the carcinogenic process suggests that measurement of mutation rates in the lung and tracheal cells could provide such a standard.

Normally, mutation rates are measured by determining the proportion of cells that can form colonies under conditions that permit mutant cells to grow but not unmutated cells. This restricts the cells in which measurements of mutation frequency can be made to those for which there are excellent culture conditions available. Recently, however, we have developed a technique designed to bypass these difficulties and to permit measurement of mutation rates in a variety of primary cell types that can be maintained in culture but not cloned efficiently, such as those of lung and trachea. The concept has been shown to work successfully in the CHO cell line where a wide variety of mutagens were detected and the assay validated. The assay detects mutation to diphtheria-toxin-resistance, one of the standard loci used in the traditional colony-formation assays. The resistance to the toxin, which acts by inhibiting protein synthesis, is detected not by colony formation but rather autoradiographically after exposure of the intoxicated cell population to tritiated leucine. Mutants resistant to the toxin will continue to synthesize protein and thus will be labelled, whereas cells that have been killed by the toxin will not. The conditions for a successful assay were indicated by the work in CHO cells, which has been published [Ronen et al, PNAS 81 (1984)].

Since then, work has proceeded on the mammary, colonic, and lung epithelia which are at various stages of development. In the mammary and colonic epithelia, the conditions for the assay have been worked out and the assay applied to model carcinogens active in these tissues. In the lung and t[illegible]hea, which work was begun much more recently, we have succeeded in developing and standardizing the isolation and culture techniques sufficiently well so as to permit commencement of the experiments that will determine the appropriate selection conditions.

FACTORS THAT INFLUENCE ASSESSMENTS OF HEALTH EFFECTS OF AIR POLLUTION

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Key words: Health Effects, Air Monitoring, Air Pollution, Exposure, Air Particulates.

ABSTRACT

Health effects of air pollution were examined in 30 asthmatics and 14 healthy non-asthmatics. The objectives were: (1) to assess exposure in 4 ways - personal (P), inside (I) and outside (O) the home, and at a fixed air pollution monitoring site (GMOE) in downtown Toronto; (2) to examine the relationship among the estimates of exposure; and (3) to assess the relative strength of the four estimates of exposure as demonstrated by its association with measures of health effects. Small portable multipollutant samplers for nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter were carried by the subjects, placed inside and outside the home and at a downtown Toronto air pollution monitoring station. Subjects were each visited on approximately 20 days; pulmonary function (spirometry) was assessed in the morning at the beginning of sampling, and again at the end of the day when sampling was terminated; a questionnaire was completed (symptoms, medications, daily activities and exposure to other potential irritants).

Analyses have been performed to measure the relationship between estimates of pollution exposure, home and lifestyle characteristics, and season of the year on symptoms and pulmonary function. The effect of season is very strong both for pulmonary function and symptom frequency. Furthermore, the relationship between pollutant exposure and pulmonary function is strongly dependent on season.

Regression analyses have been performed to determine whether the estimate of exposure using the personal monitor, our gold standard, can be replaced with a linear combination of 2 or 3 of the other three exposure estimates (I, O, GMOE). On days when an individual had spent a large proportion of his indoor time away from home, the predictive ability of the regression model was weak, as would be expected. However, for the subset of days on which the time spent indoors was only at home, the multiple correlation coefficient for the predictive model was 0.81. This finding has the potential for greatly reducing the costs of exposure monitoring in epidemiologic studies.

ENVIRONMENTAL MODELLING OF TOXIC SUBSTANCES IN SOUTHERN ONTARIO

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Key words: Southern Ontario, Organics, Environmental Fate, Partitioning Model.

ABSTRACT

It is possible to develop methods of predicting the concentration of organic contaminants in the Southern Ontario Region from a knowledge of:

(i) the magnitude of local emissions to air, water and soil, both past and present;

(ii) the magnitude of advective inflows in air and water from other regions;

(iii) the physical-chemical properties of the chemicals as they influence partitioning tendencies between the media of air, water, soil, sediment and various biota;

(iv) the reactivity of the chemicals in these media which controls the chemicals' persistence; and

(v) the intermedia transport properties of the chemical, especially air-water, air-soil and sediment-water exchange.

A Level IV fugacity model has been devised which attempts to predict the time-dependent concentrations of specific chemicals in the Region from these input data. The model has been applied to a number of chemicals for which approximate emission data and prevailing concentration data are available. Reconciling the model with the prevailing concentrations requires comparison of the single predicted mean concentrations with a distribution of environmental concentrations in each medium. The Weibull distribution function has been found to be particularly advantageous. The principal difficulties are uncertainties about emission rates and prevailing concentrations.

If the model can be calibrated and validated, it could be an invaluable tool for exploring and documenting the behaviour of these contaminants, for elucidating dominant human exposure routes, for testing the effects of emission control measures and for determining, with the help of monitoring data, if a particular region is suffering from an unusually high concentration of a specific contaminant.

DIAGNOSTIC TESTING OF THE SWARU INSTALLATION IN HAMILTON

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Key words: SWARU, Hamilton, Diagnostic Testing, Waste Incineration, Organics, Dioxins, PCBs, Stack Emissions.

ABSTRACT

The first measurements of the stack emissions of dioxins and furans at the SWARU installation were done in three tests in 1982, as part of a study progam on the formation of these species at municipal incinerators in Ontario. The test emissions were in excess of the limits set by the Provisional Guideline for stacks, and consequently, the plant was ordered to cut back on the refuse incineration rate. A comprehensive program, known as diagnostic testing, was carried out in 1983 to establish the limits for safe operation of the incinerator. The program was designed conceptually by the personnel of the Ministry's Air Resources and Laboratory Services Branches and contracts were let to Envirocon and the Ontario Research Foundation to work out the details and execute the field work.

The Ontario Research Foundation was responsible for the collection and preparation of stack and process stream samples for analyses on dioxins, furans, chlorobenzenes, PCBs and chlorophenols. The Laboratory Services Branch performed the analyses and the Air Resources Branch was responsible for co-ordinating the field work. Envirocon was responsible for process monitoring.

As a result of the study, new operating limits for incineration were established, maintenance procedures were modified, and installation of additional process gas monitors and of additional control equipment for the removal of particulates from the stack emissions were recommended.

CHEMICAL AND PHYSICAL CHARACTERIZATION OF AIRBORNE PARTICULATES AND THEIR SOURCES THROUGH MULTIELEMENT ANALYSIS AND RECEPTOR MODELLING

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Key words: Particulates, Air Pollution, Multielement Analysis, Receptor Modelling.

ABSTRACT

Source identification and apportionment of ambient airborne particulates is important if air pollution is to be more stringently controlled in urban, industrialized regions. These are locations where traditional air pollution dispersion models are at a disadvantage because of the investment of time, funds and manpower required to diligently characterize all the major contributing emission sources. On the other hand, receptor models utilize measurements at just one or a few limited receptor sites, and the contributing sources are then statistically evolved by analysis of a set of data factors: detailed chemical composition of ambient particulates, meteorological data, particle-size distributions and site locations.

In this research, radioanalytical methods are being applied for the simultaneous analysis of about 30-35 chemical elements in airborne particulate matter sampled in the greater Metropolitan Toronto area during the period from January 1984 to the present. In the first one and a half years of the funded project, all the results obtained together with the relevant meteorological data were subjected to statistical factor analysis with the objective of deducing, from the multielemental chemical composition data itself, the major contributing sources of air pollution in the Toronto atmosphere. Factor analysis indicated that six sources were distinguishable: wind-blown soil grains, automobile exhaust, refuse incineration, winter road salt, oil combustion and an unidentified source of arsenic. Elemental concentration profiles for the several elements that characterized each of these six sources were input into a comprehensive chemical element mass balance calculation to determine quantitatively the relative contribution of each source to the ambient Toronto aerosol.

The results showed that re-entrained soil contributed 67% to the inorganic portion of atmospheric air particulate matter, automobile exhaust contributed 15%, road salt 12%, and the other sources lesser amounts. A limited additional study of particle-size distributions, especially for Al, Fe, Sc, As, Br, Cl, Zn, Mn and V, provided some additional details on aerosol characterization.

STUDY OF CONDITIONS FOR CONDENSATION AND DESORPTION OF PCDD ON PARTICULATE MATTER UNDER STACK SAMPLING CONDITIONS

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Key words: Incineration, Flyash, Dioxin, GC-MS.

ABSTRACT

Municipal incinerator flyash was heated in a pyrex tube under a flow of high-purity nitrogen. The levels of polychlorinated dibenzo-p-dioxins (PCDD) in the heated samples were determined using gas chromatography/mass spectrometry (GC/MS) and compared to levels in unheated samples.

In a time and temperature study where temperatures from 100° to 200°C and heating times from 16 to 48 hours were investigated, PCDD levels decreased to 10 to 30 per cent of the levels in unheated samples. The PCDD levels were independent of heating time and temperature under the above conditions. About 10 per cent of the PCDD could not be desorbed and are thought to be chemisorbed on the surface of the flyash particles. Heating the flyash at 120°C for 2 to 6 hours desorbed 15 to 38 per cent of the PCDD. The desorption rates for the PCDD congeners were estimated to be 0.037, 0.086, 0.15 and 0.23 ng/g/hr/L for tetrachloro-,pentachloro-, hexachloro- and heptachlorodibenzo-p-dioxins respectively. At constant temperature, these rates appear to depend mainly on the amount of the particular PCDD congener originally present on the flyash, not on physiochemical properties such as vapour pressure or dipole moment. When expressed as per cent/hr/L, desorption rates for the PCDD congeners were not significantly different from each other. The average value was 0.78 per cent/hr/L. Desorbed PCDD were adsorbed onto exhaustively extracted flyash placed in the tube downstream of the heated sample. There was no evidence of decomposition of the PCDD under the experimental conditions.

ASSESSMENT OF TOXICITY OF INGESTED AND INHALED HALOAROMATIC HYDROCARBONS

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Key words: Organics, Toxicity, Dioxins, Health Effects, Immunosuppression.

ABSTRACT

Previous studies in our laboratory have shown that 2,3,7,8-TCDD and related haloaromatic hydrocarbons such as Aroclor 1254 and 3,4,3',4'-tetracholorobiphenyl suppress the immune response. In the case of TCDD, suppression of the generation of cytotoxic T cells (CTL) occurred at a cumulative dose of 0.004 ug/kg (12 pM or 4 parts in 10^{12}) in chronically treated inbred laboratory mice. This immunosuppression proved to be 100-1000 times more sensitive an index of TCDD effect than was induction of hepatic P_T450 and related enzyme systems. Further, inhibition of CTL generation by TCDD was associated with an increased mortality following challenge with herpesvirus type 2.

Studies designed to elucidate the mechanism of immunosuppression by TCDD have shown that TCDD promotes the production of suppressor T cells. Sensitivity to TCDD is determined in part by genes at the Ah locus in mice and, using chimeric mice created by replacing the lymphocyte component of the immune system of TCDD-sensitive mice with cells from TCDD-resistant mice and vice versa, we were able to show that immunosuppression by TCDD is mediated through the non-lymphoid cells of the host. Since T cells develop in the thymus gland under the influence of thymic epithelium, and since epithelial cells have been noted to be particularly sensitive to TCDD, we proposed that TCDD acted via the thymic epithelia to promote suppressor T cell production.

Results from current studies have provided several new and relevant pieces of information:

1. Removal of the thymus gland from 6- to 8-week old mice renders them totally resistant to immunosuppression by low level TCDD exposure. The importance of the thymus is thus confirmed.
2. Thymus function declines with age. We found that 8-month old TCDD-sensitive mice that had achieved 20%-25% of their life span (roughly equivalent to a 15- to 17-year old human) were readily suppressed by 12 pM TCDD, whereas 13-month old mice that had completed approximately 36% of their life span (roughly equivalent to 22- to 28-year old individuals) and 22-month old mice were completely resistant to suppression by TCDD. These data have an interesting parallel in that in the study by Knutsen of humans exposed to 20 - 100 ppb for 2 years (or to 100 ppb for 6 months) in Time's Beach, Mo., evidence of immunosuppression was seen primarily in the group under the age of 18.
3. While TCDD administered orally in food has been shown to suppress CTL generation, a further experiment has indicated that a substantially greater amount of TCDD must be given orally to achieve the same immunosuppressive effects as 12 pM injected parenterally. A preliminary dose-response study suggests that the difference in oral vs parenteral dose required may be on the order of 1000 fold.

These data have significant implications for the setting of zero biological effect exposure limits for different groups of individuals who may be exposed to TCDD and related haloaromatic hydrocarbons by different routes. Further, since the thymus-mediated immunosuppressive effects appear to be reflected in alterations in the surface markers on blood T lymphocytes both in mice and in humans, it may be possible to monitor exposed individuals using a simple non-invasive technique.

NICKEL CARBONYL AMBIENT MONITOR

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Key words: Nickel Carbonyl, Air Pollution Monitoring, Analyzer.

ABSTRACT

The Ministry had a requirement for an ambient Nickel Carbonyl monitor capable of making measurements down to the Provincial limits.

The only commercially available Nickel Carbonyl monitor was not sufficiently sensitive to fulfil the Ministry's needs. Furthermore, the manufacturer was not interested in upgrading their instrument in light of the expected market.

We took a commercial NO/NO_x chemiluminescent analyzer and modified it to measure Nickel Carbonyl. To measure $Ni(CO)_4$ rather than NO, two major changes were made to the plumbing of the instrument. An additional input to allow the addition of carbon monoxide to the air stream and a prereactor to remove NO were added. A permeation-based air dryer was added to the inlet of the instrument to remove problems encountered with water vapour. The filter in front of the photomultiplier was changed to give maximum sensitivity towards $Ni(CO)_4$ while discriminating against $Fe(CO)_5$ and NO. The reaction vessel was increased in size to improve sensitivity. A calibration protocol was developed to allow in-situ calibrations of $Ni(CO)_4$.

RETROSPECTIVE CORRELATION SPECTROSCOPY AND ITS APPLICATION TO ATMOSPHERIC MONITORING

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Key words: Air Pollution, Correlation Spectroscopy, Emission Monitoring.

ABSTRACT

Field spectra of skylight recorded after its transmission through an atmospheric plume of absorbing material contain spectral absorption signatures of the plume species as well as of normal Telluric and Fraunhofer features.

Traditional correlation spectroscopy uses phase sensitive analogue methods to interpret the spectral signal which passes through a correlation mask, oscillated at the focal surface of the spectrometer. The mask is an alternating series of slits and opaque regions which models some aspects of the absorption spectrum of one of the molecular plume species.

In retrospective correlation spectroscopy, the correlation mask is a mathematical function M(L), representative of the absorption cross-section o(L) of one of the plume species. Correlations C(z) between the mask function M(L-z) displaced by z and the (digital) field spectrum I(L) are interpreted in terms of species column density NX in the optical path through:

$$C(z)/I_o = A\text{-}N.X.F(z) \qquad (1)$$

where I_o is non-absorbed field spectrum intensity, A is the total mask transmission area, F(z) is the convolution between o(L) and M(L-z), N is the species concentration, X is its path length, and L is the wavelength.

Last year a report was given of an analytical model study of the retrospective correlation spectroscopic method based on simple empirical representations for the absorption cross-sections and of the mask[1]. This work led to equation (1) above and suggested a number of ways in which the correlogram could be used to determine column densities of plume species. During the current year, the work has been extended as follows:

(a) The mathematical modelling has been enhanced to include more realistic numerical representations of the SO_2 spectrum, and a number of different mask functions have been investigated.

(b) Laboratory simulations of the field spectra have been made using a xenon high pressure lamp, an SO_2 absorption cell, and a medium resolution scanning spectrometer.

(c) The results of (a) and (b) above have been compared to demonstrate the practical efficacy of the retrospective correlation method.

(1) R.W. Nicholls, "Model Studies of Retrospective Correlation Spectroscopy" Applied Optics, 24, 2046-2048, 1985.

THE RAPID SCREENING OF MUNICIPAL REFUSE INCINERATOR FLY-ASH AND STACK GAS FOR PCDD/PCDF USING A TRANSPORTABLE TANDEM MASS SPECTROMETER (GC/MS/MS) SYSTEM

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[1]SCIEX
[2]Ministry of the Environment

Key words: Refuse, Incineration, Flyash, Stack Gas, Dioxins, Furans, GC-MS.

ABSTRACT

The formation of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF) is strongly linked to the incineration of municipal refuse. To date, there has been no study which demonstrated clearly what, if any , incinerator operation parameter(s) this production correlates with. Part of the problem in determining such correlations is that testing for PCDD/PCDF is an expensive and time-consuming effort. This paper describes a rapid analytical approach using gas chromatography (GC) coupled to tandem triple quadrupole mass spectrometry (MS/MS). This combination has been demonstrated to be more specific than conventional GC/MS while requiring less time per analysis. Furthermore, the instrument used in the present work (the TAGA 6000E manufactured by SCIEX) is fully transportable, permitting it to be driven to the incinerator for rapid on-site PCDD/PCDF analysis. The analysis of fly-ash and stack gas will be described and analytical results compared to GC/MS analyses performed on the same samples.

BLOOD LEAD AND ASSOCIATED RISK FACTORS IN ONTARIO CHILDREN - 1984

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Ontario Ministries of Health, Environment and Labour

Key words: Blood Lead Survey, Lead Exposure, Environmental Health, Exposure Assessment, Air Pollution.

ABSTRACT

Lead exposure from the external environment as well as the home has received much attention in the past decade. In the absence of information on the blood lead levels of Ontario children who are not exposed to a known source of industrial emissions, the Ministries of Labour, Environment and Health undertook the Ontario Blood Lead Study. The purpose of this study was to determine blood lead levels in Ontario children and to identify those demographic, environmental and lifestyle characteristics related to higher blood lead levels.

1315 children aged 7 and younger in selected urban, suburban, and rural areas of Ontario were sampled for analysis of blood lead. Blood lead concentration was determined in finger prick blood samples by graphite furnace atomic absorption spectrophotometry. Measurement of lead in air where children live, lead in tap water at their school, and lead in soil in areas where they play was carried out. Traffic density was measured at the largest intersection nearest to the children's school. A random sub-sample of 800 families of children tested for blood lead was assessed for the presence of risk factors which may be associated with elevated blood lead concentrations.

Urban children had higher geometric mean blood lead levels (12.0 ± 4.4 ug/dl) than suburban children (10.0 ± 3.5 ug/dl), and they in turn had higher blood lead levels than rural children (8.9 ± 3.9 ug/dl), a statistically significant difference. 4.3% of all children were at or above the alert level of 20 ug/dl; the proportion above the alert level did not differ between urban, suburban and rural children. Blood lead levels were slightly higher for males than females and for pre-schoolers aged 3 and 4, compared to school age children aged 5 and 6. The distribution of blood lead levels among these children was lower than that of children in point source areas.

Multivariate statistical modelling resulted in a set of characteristics which best explained the differences in children's blood lead levels: younger age, lower family socio-economic status, hot water radiator heating in the home, number of gas stations within six blocks of residence, number of industries within six blocks of residence, residence within one block of a major highway, and geographic site (Toronto, Windsor, Etobicoke, Scarborough, Longwoods, Nanticoke-Walpole). Environmental measurements of lead in air and soil, together with neighbourhood traffic density, were equivalent to "geographic site" in their ability to predict variations of blood lead levels among children. These environmental measurements and neighbourhood characteristics were meaningful surrogates for "site" in being able to estimate the potential contribution to the lead burden of children.

Five of the seven factors most closely related to children's blood lead levels are measures of lead in the physical environment. The prime contributor to air lead in the areas tested was lead in gasoline. Reduction of lead in leaded gasoline may be expected to produce some reduction of blood lead levels in children in Ontario.

PRODUCTION OF OZONE INSENSITIVE WHITE BEAN VARIETIES

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Key words: Ozone, Beans, Air Pollution, Food Crops.

ABSTRACT

White bean, also called navy or pea bean, is the predominant common bean (Phaseolus vulgaris L.) type grown in Ontario. About 40,000 hectares of white beans are cultivated annually in southwestern Ontario and generate a farmgate income of approximately $40 million. The currently licensed and recommended white bean varieties are susceptible to leaf damage following episodes of high atmospheric ozone concentration during the growing season. Ozone-induced leaf damage, or bronzing, has been estimated to reduce white bean yields by more than 30%. Because of this culture's reliance on fossil fuels, it seems unlikely that levels of ozone and other airborne contaminants will decline in the short term. The objective of this project is to develop commercially acceptable white bean varieties that carry genetic protection against leaf damage for ozone and other airborne contaminants. In addition, we are developing an objective method of measuring ozone leaf damage by digitized video image analysis.

Previous screening trials at the University of Guelph identified three ozone insensitive common beans. These bean lines were used as insensitive germplasm donors in crosses with commercially acceptable, but ozone sensitive white beans. Crosses among these three donors and several adapted white bean varieties and breeding lines resulted in the development of 12 unique families from which 77 potentially resistant and commercially acceptable homozygous white bean plants were selected. Seed from these 77 plants were germinated in a terface clay potting mixture. Fourteen-day old seedlings were moved to growth chambers and exposed to 0.15 ppm ozone for 6 hours during each of four consecutive days. On the fifth day, visible injury of the two unifoliate leaves was rated using a modified Horsfall-Barratt scale. The score for each of the 77 lines was compared to that of its white bean and common bean parent using the Student's t test.

Fifteen of the 77 selected lines showed significantly less leaf damage after exposure in the growth chamber than their sensitive white bean parent. The 15 insensitive selections were confined to three of the 12 families, with all 10 selections from one family showing significantly less leaf damage. Fourteen of the 77 selections showed significantly more leaf damage than their insensitive common bean parent. The 14 sensitive selections were confined to four of the 12 families. These results suggest that a white bean variety with improved ozone insensitivity may be developed. Additional study is necessary to evaluate the reaction of these selections to ozone in the field, and to determine the agronomic and commercial acceptability of these selections as white bean varieties.

SYNTHESIS OF OXYGEN AND SULPHUR PAHs OF INTEREST IN ENVIRONMENTAL POLLUTION AND TOXICOLOGY

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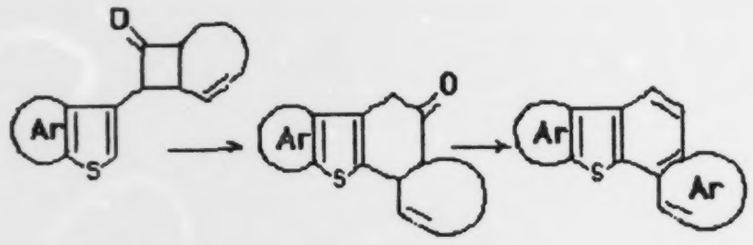
Key words: PAH, Synthesis, Analytical Standards.

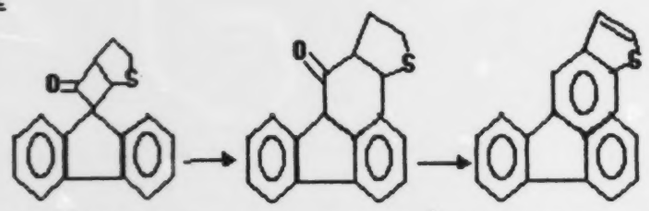
ABSTRACT

Our research program has focussed on the synthesis of oxygen and sulphur heterocyclic PAHs which are isoelectronic with known carcinogenic carbocyclic PAHs. We have also prepared PAH ketones, specifically, annelated fluorenones which represent environmental oxidation products derived from the hydrocarbon precursors and used as reference standards for the complete environmental analysis of these compounds. The methods used were ones developed in our laboratories involving aryl-substituted bi- and tricyclic cyclobutanones as intermediates. The general methodology is indicated in the following schemes:

Scheme1



Scheme2



The above schemes illustrate the selective β-cleavage process for cyclobutanone carried out under acidic conditions and leading to angular fused aromatic derivatives. The same starting materials can be used to prepare the linear fused heterocycles by selective α-cleavage reactions brought about under basic conditions. The details of the particular reactions as well as the specific heterocyclic PAHs prepared will be discussed. In addition, the preparation of fluorenone annelated PAHs from the dehydration of diarylcarboethoxymethanols under strong acid conditions and their conversions to the corresponding fluorenones will also be included in the presentation. These PAH fluorenones are likely environmental oxidation products and their detection and analysis in environmental samples would represent a more complete assay of the presence of their PAH precursors.

THE DISPERSAL OF AIR PARTICULATES ON A SHORT AND LONG-TERM TIME SCALE

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Key words: Particulates, Air Quality Monitoring, Multielement Analysis, Lead, Air Filters, X-ray Analysis.

ABSTRACT

Two streak filters, having a time resolution of 2 hours, have been used to monitor the air particulates near an intersection in Kingston over a two-week period in June. One filter was placed $\sim$100 m from the intersection while the second was placed $\sim$ 700 m away in the backyard of a home. The local meteorological conditions were determined with a micro-processor based weather station which formed part of the sampling device. Wind speed and direction, temperature, rainfall and humidity were sampled every 7 seconds and averaged over a half-hour so that the conditions under which the air particulates were collected were known.

The particulates on filters were analyzed for their elemental composition with particle induced X-ray emission (PIXE) using the Queen's Van de Graaff accelerator. Each filter contained a deposit for one week and two of these for the same week, one from each site, have been analyzed. Al, Si, S, Cl, Ca, Cr, Mn, Fe, Cu, Zn, Br and Pb were found in measurable quantities at both sites. The average levels for all the elements except Br and Pb were the same at the two monitoring sites, indicating that elements from natural sources and from fossil fuels are distributed uniformly in this region. Near the intersection, the ratio of Br to Pb was 0.21, indicative of automobile emission. In the backyard, the concentrations of Br and Pb were lower by factors of 4 and 2 respectively. As previously observed, high Pb concentrations (up to 0.6 ug/cm^2) correlate strongly with vehicular traffic especially for the station nearer the intersection. There is some indication that the wind velocity, as measured by the station near the intersection, can account for the difference in the high lead levels between the two stations although this is not completely clear. Further evidence for this will be obtained when the filters from the second week are analyzed.

DOSE-RESPONSE STUDIES OF GASEOUS POLLUTANTS ON FOOD CROPS

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Key words: Ozone, Agriculture, Food Crops, Air Pollution Effects.

ABSTRACT

Controlled environment ozone dose-response studies were performed on several food crop species using cultivars widely cultivated in Ontario. Two or three week old cabbage, carrot, and tomato plants were exposed to 0, 0.1, 0.2, or 0.3 ul/l for one 7-hour period. Two-week old "Cherry Belle" radish plants were used as the indicator species in the experiments. Immediately following exposure and also 3 days later, the plants were rated for injury. Three days following ozone exposure, leaf area and leaf and/or stem fresh and dry weights were measured where applicable. For carrot and tomato, significant negative linear dose-response relationships were determined for all growth parameters at both ages at all ozone levels. The reactions of cabbage to ozone differed according to age. The results of the 2-week old plant growth studies indicated a quadratic response to dose with no significant leaf growth reduction occurring until ozone reached 0.2 ul/l. However, no significant ozone effects were observed in the three-week old plants. Field studies in open-top chambers were conducted during the summer using the same species and treatment regimes to determine what type of comparison can be made between indoor and outdoor ozone studies.

Asparagus plants were subjected to the same ozone treatments as previously described. Frond and spear areas, and fresh and dry weights and injury were determined. No significant differences in growth were found. An experiment was performed using 2- and 3-week old carrot plants to determine dose-response to ozone at 0, 0.06, 0.12 or 0.18 ul/l for one 7-hour exposure. A significant ozone effect was observed at both growth stages with growth significantly reduced at 0.18 ul/l. A long-term study to determine ozone effects on carrot shoot growth and root productivity was conducted. Beginning at 16 days of age and once each week for 5 consecutive weeks, the plants were exposed to one 7-hour period of ozone (0, 0.06, 0.12, or 0.18 ul/l). Data analyses and interpretation of data have not been completed at this time, but will be by the time of the Technology Transfer Conference.

Two experiments were conducted with 2-week old tomato plants to determine if imidazolidinyl urea (IDU), a compound similar in structure to EDU, would serve as an ozone protectant. In one experiment, IDU levels of 0, 100, 500, or 2500 ug/ml were sprayed on plants 3 days prior to ozone exposure (0, 0.1, 0.2, or 0.3 ug/l). No evidence was observed for protection against ozone injury. A second experiment also indicated no protection from 0.2 ul/l of ozone with spray applications of 2500 or 10000 ug/ml of IDU applied 0, 1, or 3 days prior to exposure.

USE OF THE DIRECT SAMPLE INSERTION DEVICE FOR SAMPLE VAPORIZATION IN THE INDUCTIVELY COUPLED PLASMA FOR ATOMIC AND MASS SPECTROMETRY

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Key words: ICP-MS, Multielement Analysis, Sample Insertion Devices.

ABSTRACT

The Direct Sample Insertion Device (DSID) will be described, and its application in several areas will be discussed. For liquid samples, the wire loop DSID has demonstrated sub-ppb detection limits for both Atmomc Emission and Mass Spectrometry. Precision better than 1% appears to be possible using an automatic injection system developed in our laboratory. A number of advantages for both optical and mass spectrometry appear to be provided by the wire loop configuration. These include temporal resolution of possible interfering species and elimination of water vapours. The performance of the liquid wire loop DSID system will be discussed in some detail for both optical and mass spectrometric configurations. The systems will be compared and contrasted.

Solid sample introduction into the inductively coupled plasma for atomic emission spectroscopy will be discussed. Considerable success has been achieved with human hair. Undigested single hair samples have been inserted. Precision of the technique seems to be dependent on hair and not on the DSID for Cu. Some questions remain as to the applicability of the technique for high accuracy determinations; however, the accuracy is quite adequate for surveys. More difficult solid sample types will also be discussed.

IDENTIFICATION OF SELECTED PAHs IN A HAMILTON, ONTARIO AIR SAMPLE BY SHPOL'SKII SPECTROSCOPY

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and
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Key words: PAH, Trace Organics, Atmospheric Emissions, Shpol'skii Spectroscopy, Hamilton.

ABSTRACT

Shpol'skii Spectroscopy is used to establish the presence of selected PAHs, including both benzo(a) and benzo(b) pyrenes, in an air sample taken from the vicinity of steel refineries in Hamilton, Ontario. The selected PAHs are taken from a list of priority PAHs drawn up by the Ontario Ministry of the Environment. The sample analyzed is an HPLC fraction of a Hi-Vol sample provided by IEC Beak Analytical Services and is diluted with n-octane in preparation for analysis by Shpol'skii Spectroscopy. The dilute solution is flash frozen in liquid nitrogen and then cooled to 12°K. Preliminary identification is made by first obtaining a fluorescence spectrum of the environmental sample using a pulsed nitrogen laser at 337 nm as the excitation source and then comparing this with reference spectra from a library of fluorescence spectra of authentic PAHs in n-octane matrices. To confirm the tentative identification, use is made of excitation spectra of the environmental sample obtained with the aid of a pulsed tunable dye laser. The fluorescence from the sample is observed with a monochromator set at the wavelengths of individual fluorescence spectral features used to make the preliminary identifications. These excitation spectra are compared to reference spectra in a library of excitation spectra of authentic PAH samples in n-octane matrices. The final identification of PAHs in the environmental sample is compared with that obtained by HPLC analysis of the same environmental sample in the Ministry of the Environment's laboratories.

THE EXCHANGE OF AIR PARTICULATES BETWEEN THE INSIDE AND OUTSIDE OF A BUILDING

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Key words: Particulates, Air Quality, Multielement Analysis, Indoor-Outdoor Air.

ABSTRACT

The element composition of air particulates collected simultaneously inside and outside a school has been determined with particle induced X-ray emission (PIXE) using the Queen's Van de Graaff accelerator. The indoor stations were placed in three sections of a school which are ventilated separately and which are more or less isolated from each other, one a classroom, the second an office and the third a workshop.

The particles were collected on streak filters operating with a time resolution of two hours so that time correlations between the indoor and outdoor air could be monitored. Two filters at each position, each of one week duration, were collected. One indoor, from the classroom, and one outdoor filter from the same time period have been analyzed, and the other six filters will be analyzed shortly.

Al, Si, S, Cl, Ca, Cr, Mn, Fe, Cu, Zn, Br and Pb were observed both inside and outside the school. The levels of Al, Si, Ca, Br and Pb were all lower by a factor of 2 - 3 inside the school than outside, Cl appeared to be higher and the others the same. Besides Pb and Br which were expected to have elevated levels of short duration due to the traffic pattern at the intersection, several other elements showed high levels of short duration outside the school and so the exchange of air into and out of the building could be determined. If a high level appeared outside the school, an elevated level inside the school was measured within two hours, the time resolution at which the system was operated. The actual level inside the school was not always the same fraction of that which appeared outside the building and this is not understood. Generally, the level inside this classroom was about a third of that outside. Whether this is the same for the other locations will be determined when the other filters are analyzed.

FEASIBILITY OF DETERMINING SO_2 MASS EMISSION FLUXES BY STACKSCANNING

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Key words: Stack Emissions, Emissions Monitoring, Sulphur Dioxide.

ABSTRACT

The MONITEQ PLUMETRACKER has a proven record for being able to remotely measure SO_2 concentrations in overhead plumes several kilometers downwind of a stack. During 1984, with the assistance of the Ontario Ministry of the Environment, MONITEQ undertook a study to assess the feasibility of using a PLUMETRACKER from a stationary platform to measure SO_2 emissions at the mouth of a stack. A 5-metre high test stack normally used by the Ministry to train personnel to measure plume opacity was used for these investigations. Parameters studied included varying SO_2 concentrations, plume opacities, background sky conditions and the effects of the sun and sight elevation angles. The SO_2 concentrations exiting from the stack were verified using an in-stack continuous emission monitor (CEM).

The work established that there is a strong correlation between the CEM value and the PLUMETRACKER value, but that the nature of the correlation varied from experiment to experiment. The correlation desired is a linear, one-to-one relationship between the CEM measurement and the PLUMETRACKER measurement (as was obtained in an initial laboratory comparison). The field results obtained did yield linear relationships, but they showed three forms of variation from the ideal: an offset; a slope other than one; and scatter in the points. This behaviour is ascribed to several causes, including instrumental effects and those related to the experimental procedure.

The principal instrumental effect is believed to be caused by a variation in response within PLUMETRACKER's rectangular field of view. Such performance, if true, is not noticeable in the instrument's normal mode of operation wherein the angular extent of the plume (some distance downwind of the source stack) greatly exceeds that of the instrument's field of view (FOV), but is significant under the stationary conditions of this study wherein the plume size at the stack mouth is much smaller than the instrument's FOV. The effects of the other parameters under study were small in comparison to the aforementioned and it was therefore not possible to quantitatively determine their impact upon the measurement.

The study concluded that the PLUMETRACKER and the measuring technique can be modified to overcome the variable response problem of the PLUMETRACKER FOV. The proposed solution is to reduce the instrument's FOV and adopt a true scanning technique whereby the instrument's FOV is uniformly scanned across the mouth of the stack.

GAS PHASE PHOTOCHEMISTRY OF POLYCHLORINATED BIPHENYLS

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Key words: PCBs, Photodecomposition, Air Pollution, Contaminant Transport, Aromatic Hydrocarbons.

ABSTRACT

The quantum yields of photodecomposition of a series of polychlorinated benzenes and polychlorinated biphenyls have been determined in the vapour phase. Most of the compounds studied decompose with a photochemical efficiency in the range of 10 - 20%. By making use of literature data on typical ambient concentrations of PCBs in urban air, and literature data on the variation of the solar intensity with wavelength, it has been concluded that photodecomposition of these substances is very slow in absolute terms. Consequently, chlorinated aromatic hydrocarbons are able to travel through the atmosphere and to be deposited unchanged far from their point of emission into the atmosphere. These conclusions are in line with practical experience. Details of the methods used for the actinometry and for the calculations will be discussed.

A FUNDAMENTAL STUDY ON THE DEPOSITION OF AEROSOLS ON CYLINDERS IN TURBULENT CROSS FLOWS

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Key words: Aerosol, Deposition Rates.

ABSTRACT

The deposition of aerosols on non-streamlined surfaces such as cylinders and spheres in ideal flow (viscous or inviscid flow) has been studied in some detail. Under such flow conditions, the deposition process has been modelled in terms of the inertial impaction, interception and Brownian diffusion collection mechanisms. Carefully designed experiments to test these models have shown them to be adequate for the conditions under which they were developed.

However, recent experimental results on the deposition of aerosols on single wires in turbulent cross flow yielded significantly higher collection efficiencies than the values predicted by the classical mechanisms. To explain the increased collection efficiency, it is necessary to consider eddy diffusion of the particles due to the free stream turbulence as a prime mechanism.

Based on the concept of eddy diffusivity, a turbulent diffusion model has been developed to predict the experimentally observed deposition rates. The model is essentially the solution of the continuity equation and equations of motion for the particles, with the assumption that within the boundary layer the fluid-particles closely follow the fluid streamlines. From physical reasoning, the eddy diffusivity profile within the boundary layer is assumed to have the same shape as that near a flat plate.

The model equations are solved with the solution of the boundary layer equation in which the external flow is assumed to be for potential or for experimental flowlines. Computed deposition rates are in good agreement with the experimental results when the solution of the turbulent diffusion model is based on the solution of boundary layer equations where experimental flowlines are used for external flow instead of potential flow conditions. A single parameter, known as the turbulent Schmidt number, was obtained which adequately characterizes the system.

THE HAMILTON STUDY: EFFECT OF FINE PARTICLES ON THE RESPIRATORY HEALTH OF SCHOOL CHILDREN

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Key words: Hamilton, Air Particulates, Health Effects, Respiratory System, Survey.

ABSTRACT

Hamilton, Ontario, is an industrial city with a population of 300,000, situated at the western end of Lake Ontario. The level of particle pollution has historically been high, and a portion of this has been attributed to the activities of Canada's two largest iron and steel mills which are located here. Although in the last two decades air quality has improved markedly, there has been a continuing community concern about the effects of air pollution on health.

From 1979 to 1982, we carried out an epidemiological study of the respiratory health of a cohort of over 3,500 elementary school children, in whom we also determined the extent to which they were exposed to ambient particles of different sizes. Respiratory health was assessed by determining each child's respiratory symptoms and health history using a questionnaire administered to the parents. In addition, comprehensive tests of pulmonary function were carried out on the children at their schools. Particle size and concentration were measured using two networks: one of 7 to 9 Andersen 2000 cascade impactors, and another of 27 GMW Hi-Vol TSP samplers. Both networks were distributed over the area of the city. Other environmental factors thought to "confound" the relationship between respiratory health and air pollution were also examined via information collected in the parental questionnaire, e.g. parental smoking, use of gas for cooking and socio-economic status.

Results of a cross-sectional analysis of the data from the cohort in the second year of the study showed a strong effect of maternal smoking on the prevalence of cough and bronchitis, with little air pollution effect on these variables. Two pulmonary function variables, peak flow (adjusted for height) and maximum expiratory flow at 75% VC (adjusted for height) showed an association with the presence of fine particles.

EMISSION MONITORING FOR TOTAL HYDROCARBONS AT SEWAGE SLUDGE INCINERATORS

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Key words: Emission Monitoring, Organics, Sewage Sludge, Incineration, Stack Emissions.

ABSTRACT

Total hydrocarbon (THC) analyzers used in stack monitoring are based on Flame Ionization Detectors (F.I.D.).

It was recognized in the operation of THC analyzers at sludge incinerators that the F.I.D. remained operational for only a few days before failing and forcing system shut-down. To correct this situation, Amko Systems, in consultation with the Air Resources Branch, undertook this study.

Our monitoring package consisted of a heated Dilution System (ADS), developed by Amko Systems Inc., that was connected to the Ratfisch F.I.D. This in turn supplied a signal to a strip chart recorder.

The ADS was designed to (1) proportion dilution air, with use of a differential pressure regulator, into the sample stream, and (2) progressively heat the sample to a higher temperature as it is drawn toward the analyzer. Thus, the sample is fed through the filters at approximately 130°C, the capillaries at 140°C and into the F.I.D. at 160°C. The problem of condensation of high boiler organics was thus addressed.

The dilution ratio used for this operation was a moderate 1:1.

RESULTS:

The Dilution System functioned for a continuous 559 hrs. before maintenance, in the form of a 15-minute filter change, was required.

During the entire test period of 32 days, the dilution ratio stayed within 5% of the initial value.

Zero drift was, for this purpose, negligible.

The result of this project indicates our heated Dilution System to be a viable approach to achieving acceptable uptimes for hydrocarbon analyzers in sewage sludge incinerators.

SYNTHETIC STRATEGIES FOR PAHs BASED ON THE DIRECTED ORTHO METALATION REACTION

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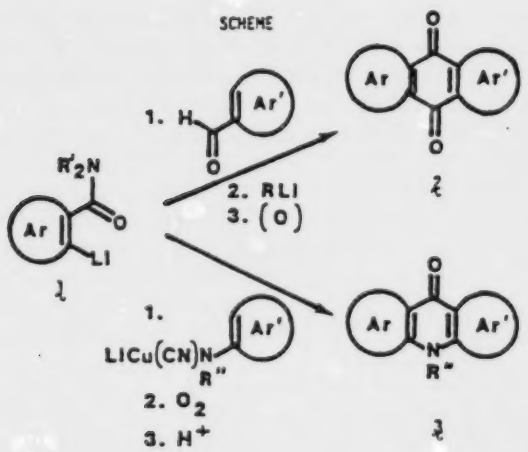
Key words: PAH, Chemical Synthesis, Analytical Standards.

ABSTRACT

Recent work in our laboratories has been focussed on the application of the directed ortho metalation reaction (Scheme) for the synthesis of a variety of PAHs and aza-PAHs of environmental interest. The increasing need for rapid and efficient access to diverse PAHs for analytical standards and for carcinogenesis research provides the impetus for the continuation of our efforts in this area. Extension of the aromatic directed metalation strategy to the synthesis of previously inaccessible halo- and methyl-PAHs by using silicon protection tactics will be described. New synthesis of silylated PAHs will be presented and the evaluation of these compounds as precursor of nitro-PAHs will be reported. Several PAHs required for Shpol'skii Effect studies, prepared by alternative methods, will also be described.

SCHEME



THE UPTAKE, DISTRIBUTION AND CLEARANCE OF SOLUBLE AEROSOLS IN THE HUMAN RESPIRATORY SYSTEM

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York University and *Ontario Ministry of the Environment

Key words: Aerosols, Respiratory System, Inhalable Particulates.

ABSTRACT

Previous work on the distribution of inhaled particles within the human respiratory system has invariably used well defined insoluble, inert, spherical particles such as polystyrene spheres. Recent experimental work by Hicks and by Pritchard et al has shown that such experiments must give misleading results since ambient aerosols are mostly soluble and will grow into droplets in the respiratory system, thus modifying their deposition and exhalation pattern. In this work, a series of experiments was performed in which volunteer subjects inhaled soluble aerosols labelled with iodine 123 and the uptake, deposition and clearance patterns were monitored by means of sodium iodide (thallium activated) detectors mounted above the head, chest and abdomen of the subject in a low background whole body counter. It is considered that the results give a realistic picture of the deposition patterns of inhaled aerosols within the respiratory system and of the uptake and clearance patterns.

DEVELOPMENT AND EVALUATION OF MICROPARTICLE-IMMOBILIZED MACROMOLECULES FOR THE SELECTIVE ACCUMULATION OF TRACE CONTAMINANTS SIGNIFICANT TO HUMAN HEALTH

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Key words: Trace Organics, Bioassays, Contaminant Accumulation.

ABSTRACT

The specificity for the accumulation of organic trace contaminants with microparticle-immobilized biomacromolecules has been tested. This assay measures the distribution of trace amounts of highly lipophilic molecules between two proteins, one immobilized in a polyacrylamide microparticle [Ekman, Lofter and Sjoholm, Biochemistry, 15, 5115 (1976)], and the other free in solution. The distribution is determined by measuring ligand bound to the two proteins after they are separated by centrifigation. We show that this method is capable of comparing the ligand binding specificity of albumin and alpha-fetoprotein (AFP) in rat and bovine systems. Rat AFP is shown to have higher affinity for docosahexaenoate ($C_{22:6}$) but low affinity of arachidonate ($C_{20:4}$) as compared to rat albumin, while bovine AFP is shown to have higher affinity for both of these polyunsaturated fatty acids as compared to bovine albumin. This difference has been attributed to the alteration of the arachidonate binding site specificity on rat AFP. The sensitivity and simplicity of this assay leads us to suggest it as a specific method of selective accumulation of organic trace contaminants from large volumes of water. The discussion will focus on the binding specificity of biomacromolecules and immobilization matrix to be used in such extraction systems.

FIELD AND LABORATORY VALIDATION OF A HIVOL DENUDER FOR MINIMIZING PAH-OZONE AND PAH-HNO_3 REACTIONS DURING SAMPLING

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Concord Scientific Corporation, Toronto

Key words: PAH, Denuder, Air Sampling, Organic Sampling.

ABSTRACT

In a previous study, a HiVol sampler was modified by placing a denuder bundle in front of, and a versatile sorbent cartridge behind, the HiVol filter. This sampling system was effective in protecting particulate material collected on the filter from ozone and also in collecting vapour phase PAH - initially present in vapour phase or volatilized during sampling. Further evaluation of the denuder was undertaken in a following project in order to determine the denuder's effectiveness towards nitrogen dioxide (NO_2) and nitric acid (HNO_3) vapour. Field sampling and laboratory experiments were performed in order to identify and quantify the oxy- and nitro-PAH in the regular and protected filters.

The denuder was shown to be effective in removing HNO_3 but not NO_2, and the lifetime of the denuder bundle towards ozone removal was established. After 6 weeks continuous exposure, the ozone removal efficiency of the bundle was 85% towards 155 ppb ozone and 90% towards 50 ppb ozone. Field tests designed to coincide with high ambient oxidant levels were not favourable, hence alternate laboratory tests were scheduled. These involved static and dynamic exposures of particulate-laden filters to O_3- and HNO_3-laden air as well as to clean air with subsequent analyses of samples. Analytical data for the laboratory experiments are currently being obtained.

A STUDY OF ADSORPTION TUBE STORAGE AND SAMPLE HANDLING TECHNIQUES FOR ORGANIC VAPOUR MEASUREMENTS

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Ontario Research Foundation

Key words: Sample Handling, Sample Storage, Organic Vapour, Air Sampling Tubes, Volatile Organics.

ABSTRACT

Measurements of trace organic components in ambient air samples often involve preconcentration on a sampling medium and subsequent laboratory analyses. The objective of this study was to assist MOE in determining optimum conditions that can be used in the handling and storage of adsorbent cartridges in order to maintain sample integrity.

Cartridges containing either Florisil/Carbosieve or Tenax/Silicalite adsorbent combinations were evaluated by dynamically loading six types of organic vapours onto the adsorbents and analyzing after subjection to various types of storage routines and transport between laboratories. Analysis of variance was used to evaluate optimum handling and storage protocols.

From the results of the study, the overall performance of the Florisil/Carbosieve cartridge generally was better than the Tenax/Silicalite cartridge with respect to measurement of the target constituents. On the other hand, the latter adsorbent combination retained most of the compounds for longer periods of time. Although some data variability occurred, the more volatile aliphatic species were usually less retained by the cartridges during storage than the aromatic compounds that were studied. Sample integrity was found to be more significantly affected by storage duration than by other factors that were considered, such as storage temperature and initial concentrations of compounds. The results implied that analyses should be done within one week of collection for some of the volatile species, and the use of a portable cooler is recommended so as to avoid temperature excursions during transport prior to analysis.

CHEMICAL SPECIATION OF AIRBORNE PARTICULATE MATTER

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Key words: Particulates, Metal Speciation, Neutron Activation Analysis, Air Analysis.

ABSTRACT

The chemical behaviour of elements present in airborne particulate material depends on the chemical forms, or species, in which these elements occur. A knowledge of these forms and their abundances is therefore required for a full understanding of the effects of airborne particulates and their hazards. This information would also be useful in determining the sources of particulates. At present, accessible and reliable techniques for determining inorganic species are lacking for many elements. This paper will describe research aimed at providing a convenient means for the speciation of inorganic solids.

The approach adopted employs reactive gas extraction, in which a gaseous reagent reacts with a solid sample to produce volatile compounds, for the removal of elements of interest from airborne particulate samples. These elements can then be recovered from the vapour phase for determination by neutron activation analysis or any other sufficiently sensitive technique. Speciation is accomplished by controlling reaction conditions so that a given element is removed from different compounds at different times. This method is expected to minimize contamination and the interaction among components of the sample that has been observed for extraction with liquid reagents.

The reactions of 1,1,1-trifluoro-2,4-pentanedione (tfa) and 1,1,1,5,5,5-hexafluoro-2,4-pentanedione (hfa) with iron and its compounds are being studied by means of radioactive tracers. The volatilisation of iron from a variety of compounds has been observed to occur readily. The temperature at which volatilisation can occur varies among the compounds studied. During the volatilisation of iron from mixtures of labelled compounds, the iron was released in a series of steps at temperatures that corresponded to those found for pure compounds. These results will be discussed and quantitative studies will be described. Studies of the reactions of thio analogues of fluorinated 2,4-pentanedione reagents will also be described.

A concurrent investigation of computer-assisted optimization of neutron activation analysis will be briefly presented.

AIRBORNE TUNABLE DIODE LASER ABSORPTION SPECTROMETER

H. Schiff, Unisearch Associates Inc., Concord, Ontario

Key words: Tunable Diode Laser, Absorption Spectrometry, Atmospheric Monitoring.

ABSTRACT

The airborne tunable diode laser absorption spectrometer (TDLAS) has been partially assembled and tested. The optical table consisting of the TDL, absorption cell and transfer optics is substantially complete. It has been shock-mounted onto a frame for aircraft use. Although the data acquisition system is not complete, it has been possible to evaluate the performance using equipment from another sepctrometer.

Due to the all-reflective optics, alignment is much easier than with our other spectrometers which use some refractive elements. The 1.5 m f/22 absorption cell performs well. Throughput has been verified to go as R^N, where the reflectivity, R, has been measured to be 0.98, and N is the number of passes up to the design limit of 142. Mirrors with an experimental dielectric reflection enhancing coating will be evaluated in the near future. Etalon noise seems to be reduced from our smaller 0.84 m absorption cell.

The one TDL we have tried for NO_2 is single mode at wavelengths free from interference from other species with adequate power, about 0.15 mW. However, this requires a temperature near 80 K. The liquid nitrogen dewar is not responsive enough near the lower end of its range for adequate thermal stability. The thermal time constant will have to be reduced. The slow drift in laser frequency caused by thermal fluctuation is a major source of noise.

Experiments are under way to find the absorption cell path length that optimizes the detection limit. This will require considerable attention to all the contributions to noise from the detector, etalons and the laser. The remaining mechanical components are expected to be ready shortly, and testing of the integrated computer interface will start toward the end of October. We anticipate that the TDLAS will be completely functional by the end of 1985. At that time, as assessment of the modifications required for operation on the DC3 will begin.

HIGHER PLANT BIOASSAYS FOR THE DETECTION OF CHEMICAL MUTAGENS

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Key words: Mutagenicity, Plant Bioassay.

ABSTRACT

Higher plants provide valuable systems for screening and monitoring environmental chemicals, both gaseous and liquid (Grant et al, 1981). Although plant screening and monitoring assay systems have been in existence for many years, they have only recently received the recognition which these sensitive and reliable systems warrant (de Serres 1978).

In this study, two higher plant assay systems are being used:

(1) Tradescantia clone 4430, heterozygous for flower colour, developed at the Brookhaven National Laboratory.
Assays: (a) The staminal hair assay system which will detect airborne and aqueous mutants.
(b) The micronucleus assay which will detect chromosome aberrations.

(2) Hordeum vulgare (barley).
Assays: (a) Root tips and pollen mother cells for the detection of mitotic and meiotic chromosome aberrations.
(b) Seedlings, for the detection of chlorophyll mutations.

Technical personnel have been established at York University where the study is being carried out. At the present time, only preliminary results on positive mutagens for testing the assay systems are available.

References:

de Serres, F.J., 1978. Introduction: Utilization of higher plant systems as monitors of environmental mutagens. Environ. Health Perspectives, 27: 3-6.

Grant, W.F., Zinov'eva-Stahevitch and Zura, K.D. 1981. Plant genetic test systems for the detection of chemical mutagens. In Short-Term Tests for Chemical Carcinogens, H.H. Stich and R.H.C. San, eds. Springer-Verlag, N.Y. pp. 200-216.

SCREENING METHODS FOR AIR AND WATER SAMPLES - INDUCTIVELY COUPLED PLASMA/MASS SPECTROMETRY FOR ELEMENTAL ANALYSIS

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University of Toronto

Key words: ICP-MS, Multielement Analysis, Analysis of Air and Water.

ABSTRACT

There are numerous reasons why the direct introduction of samples into plasmas without need for physical and chemical pre-treatment is desirable. The most important of these relate to problems arising from losses and/or contamination, potential improvements in detection limits, and the time savings and hence improved sample through-put which is obtained. There is no widely accepted method for the direct introduction of samples into plasmas. We have developed electrothermal methods. These involve use of a filament or furnace type device to produce an aerosol of the sample which is entrained in an argon stream and thus injected into the plasma. The procedure is suitable for solids and liquids. In the first year of the project, we will investigate the utility of this approach for the direct introduction of samples into the plasma of an inductively coupled plasma-mass spectrometer. The instrument parameters will be optimized, the maximum sample size will be determined and a critical comparison of filament (Re and C) and graphite furnaces will be made. Applicability to air and water samples will be investigated.

MONITORING ENVIRONMENTAL GENOTOXICITY USING SISTER CHROMATID EXCHANGES IN MICE

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Key words: Genotoxicity, Air Pollution Monitoring, Mice.

ABSTRACT

The Sister Chromatid Exchange (SCE) procedure initially used involved serial injections of bromo-5'-deoxyuridine (BudR). A switch to 50 mg BudR tablets and streamlining staining procedures has permitted the making of slides from up to 30 mice per day. A sample size of this magnitude is essential because of the sporadic variablility observed between individuals. A comparison between the two modes of BudR introduction did, however, suggest a slight decrease in sensitivity with the tablets. Furthermore, the amount of BudR absorbed varied from mouse to mouse, ranging from 4 to 45 mg. When the extremes were considered, C3H mice showed a significant correlation between the amount of BudR absorbed and the SCE levels ($r = 0.32$). However, in the range 18 to 45 mg, the correlation between the amount absorbed and SCE levels ($r = 0.12$) was not significant and so only mice which fell in this range were used. In spite of these limitations, tablet implantation was the method of choice.

C3H mice housed at the University of Windsor provided the baseline SCE values (4.31 ± 0.19) and also served as controls in each run. Ten C3H mice housed 110 km northeast of Windsor were also examined for SCEs. These gave a mean value of 3.56 ± 0.26 which suggests that, in fact, the the Windsor values may be slightly higher than the baseline should have been because of ambient industrial pollution.

Wild mice obtained from corn cribs in southwestern Ontario in 1984 gave a mean SCE value of 5.72 ± 0.08. However, both geographic and temporal fluctuations were observed. Mice collected from the Windsor and Ridgetown (96 km east of Windsor) areas in early spring, prior to crop spraying, gave SCE values of 5.70 ± 0.19 (28 mice) and 4.65 ± 0.43 (19 mice) respectively. Temporal variations were most pronounced in the Ridgetown populations where, by mid-May (spraying period) SCE counts had increased to 6.66 ± 0.24 (38 mice), the mid-June (early post-spraying) values were 5.24 ± 0.72 (30 mice) and the late July values were 4.89 ± 0.18 (21 mice). The Windsor samples gave similar results and are consistent with those reported for previous years.

The crib populations suggested that herbicide spraying had an effect on SCEs in the mice. This was supported by studies on mice put in 80-litre enclosures, half-filled with corn, placed at a number of sites in Essex County and on mice housed in 22-litre containers which were attached to sprayers during spraying.

Studies on the duration of genotoxin exposure required to increase SCE values significantly, revealed that single injections of a known mutagen such as mitomycin C or methyl methanesulfonate (MMS) almost tripled the SCE count. MMS in drinking water doubled the SCE level but only after the mice drank the treated water (at a concentration that was almost toxic) for 14 days. Exposure to a spray of bentazon (basogram), a common postemergent herbicide used on corn, showed SCE induction to peak within the first 8 hours (5.55 ± 0.15).

Finally, except where known genotoxic agents were injected interperitoneally, doubling of SCE values was seldom observed. In most instances there was only a 50 to 70% increase. This suggests that SCE levels are relatively stable and that, to date, we have studied the effects of relatively mild fluctuations in the environment. A future phase will include study of a crisis situation.

DEVELOPMENT OF METHODOLOGY FOR COMPLETE ANALYSIS OF COMPLEX ENVIRONMENTAL SAMPLES

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Department of Chemistry, University of Waterloo

Key words: Analytical Methods, PAH, Organics, Liquid Chromatography.

ABSTRACT

Polycyclic aromatic compounds (PAC) are widespread environmental pollutants produced by incomplete combustion and pyrolysis of fossil fuels and other organic matters. Studies have previously been undertaken to characterize the polycyclic aromatic hydrocarbon (PAH) content of airborne particulate matter. However, no single analytical technique is adequate for the complete analysis of a complex sample.

For complete anlaysis of Hi-Vol filter samples, two approaches are applied: (1) every sample is separated in acidic, basic and neutral fractions using the acid and base extraction method; and (2) the high pressure liquid chromatographic (HPLC) technique is used to separate samples in different fractions according to their class, such as two-ring PAH, three-ring PAH, etc. Gas Chromatography (GC) and Gas Chromatography/Mass Spectrometry (GC/MS) are applied for qualitative ad quantitative analysis of various compounds in all fractions obtained in methods 1 and 2.

The recoveries using method 1 for selected PAHs are more than 80% and PAHs were isolated in the neutral fraction. HPLC using reverse phase and normal phase columns is being used, and the recoveries for selected PAH standards are above 85%. An amine column is being used in HPLC for study of retention behaviour and recoveries of PAH standards which will be used for real samples.

PART TWO

WATER QUALITY RESEARCH

TRACE ORGANIC CONTAMINANT REMOVAL FROM DRINKING WATER

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Maclaren Plansearch, Toronto

Key words: Water Treatment, Trace Organics, Drinking Water, Granular Activated Carbon, Great Lakes, Contaminant Removal.

ABSTRACT

More than 4 million Ontario residents rely on the Great Lakes as a source of drinking water. These surface bodies continue to be contaminated with organic chemicals of industrial and municipal origin, with over 200 man-made chemicals being identified recently in the Niagara River alone. Granular activated carbon is capable of removing many of these chemicals from drinking water supplies.

A pilot plant consisting of conventional water treatment processes plus granular activated carbon (GAC) adsorption contactors is being built to study the effectiveness of both conventional and GAC processes at removing trace levels of selected organic contaminants from drinking water. The pilot plant is located at the Niagara Falls Water Treatment Plant in Chippawa.

The removal of 35 organic compounds will be monitored at natural and at spiked influent levels. These compounds include: aromatics, halogenated aliphatics, chlorinated benzene derivatives, PCBs, organochlorine pesticides and herbicides, phenols, phthalates, polyaromatic hyrdocarbons, alkanes, alcohols, aldehydes, ketones and esters. Since these compounds are at trace levels, special methods have been developed for sampling, concentrating and analyzing water containing this mixture of chemicals at nanogram per litre levels and lower.

Start-up of the pilot plant will include a program to optimize the removal of the trace contaminants in the conventional section of the treatment process by testing a variety of coagulants, coagulant aids and operating conditions.

The pilot plant design, the analytical methods development and the start-up program are discussed.

PILOT TESTING PROGRAM FOR POTABLE WATER TREATMENT FOR COLOURED NORTHERN ONTARIO WATER

T. Constantine, K. Sakomoto, and G. Lai

M.M. Dillon Ltd.

Key words: Water Treatment, Colour Removal, Ozonation, Northern Ontario, Atikokan River.

ABSTRACT

This paper describes pilot testing of colour removal processes for raw water from the Atikokan River. Processes used during the testing program, which ran from Summer 1984 to Spring 1985, include:

- ozonation;
- ozonation followed by granular activated carbon adsorption;
- ozonation followed by alum coagulation and dual media filtration;
- alum coagulation and dual media filtration.

Ozone dosages up to 8 mg/L, combined with ozone contact times ranging from 2 to 20 minutes, reduced organic colour by approximately 50 per cent. Even at 8 mg/L ozone dosage, disinfection was not complete.

EBCTs ranging from less than one minute to over one hour were used in evaluating granular activated carbon (GAC). Increases in effluent SPC indicate biological growth on the GAC. No biological regeneration of the GAC was noted under the test conditions. Colour removal on GAC ceased before 7,000 bed volumes of water were treated.

Parallel direct filtration runs show that less coagulation (alum and polymer) are required when the water is pre-ozonated.

The alternative colour removal processes are evaluated on the basis of operating cost (at Atikokan) for colour removal to 5 H.U. The secondary consideration, reduction of trihalomethane formation potential to less than 350 mg/L, is met by all processes reducing organic colour to less than 5 H.U.

Process design for a new Potable Water Treatment Plant for the Township of Atikokan, using pilot testing results, is discussed.

DEFLUORIDATION OF AMABELLE TOWNSHIP GROUNDWATER

P.J. Halliday

Proctor & Redfern Limited

Key words: Deflouridation, Groundwater, Amabelle Township.

ABSTRACT

A study of groundwater deflouridation was carried out in August 1985. Two deflouridation processes were selected for evaluation after an intensive literature review. These were:

1. Activated Alumina
2. Reverse Osmosis

Activated Alumina is currently in use in the United States. However, very little data is available on the quality and quantity of regenerant waste produced by the process. Two types of regenerant were evaluated:

1. 1% NaOH Solution

2. Hanfloc (with an equivalent caustic strength to 1% NaOH)

Rapid advances have been made in membrane technology over the past ten years. Reverse Osmosis was evaluated to assess its degree of efficiency and throughput capacity.

The results of both pilot units will be presented, with cost estimates and operational requirements for treating the Amabelle Township ground water.

SEDIMENT AND POLLUTANT ACCUMULATION IN THE HUMBER RIVER MARSH, TORONTO, ONTARIO

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Key words: Humber River, Sediment, Contaminant Accumulation.

ABSTRACT

As part of the Toronto Area Watershed Management Strategy or TAWMS study, sediment and contaminant accumulation in the Humber River Marsh was evaluated. The study area consists of a low energy fluvial system bounded by Lake Ontario in the south and Bloor Street in the north. Sediment cores were collected from the channel, floodplain and backwater pond environments present in the Marsh during the fall of 1983, and laboratory analyses were performed during the fall of 1984 and spring of 1985.

Recent sedimentation rates as measured by stratigraphy, pollen and lead-210 radioisotope analysis ranged from as low as 0.2 cm/yr. on the floodplain to as high as 1.9 cm/yr. in the backwater ponds. Cores were subsampled and tested for specific trace metals, polychlorinated biphenyls (PCBs), and the pesticide DDT and its metabolites DDD and DDE. Metal concentrations ranged from below detection limit to 7, 108, 79, 970, 85, and 190 ug/g for Cd, Cu, Cr, Mn, Ni, and Pb, respectively. Organic pollutant concentrations ranged from below detection limit to 163.4, 65.0, 93.9 and 21.3 ng/g, respectively for PCBs , DDT, DDD and DDE.

With the exception of Pb in all cores and Cd in one core, metal contamination was not considered to be significant (i.e., surface metal concentrations were not significantly greater than assumed background levels). With respect to PCBs, DDT, DDD and DDE sediment contamination was considered to be moderate. It is estimated that approximately 3000 kg of lead, 3.2 kg of PCBs, 0.4 kg of DDT, 1.3 kg of DDD and 0.4 kg of DDE are presently stored in the Humber Marsh. In general, sediments from the backwater ponds had the highest contaminant concentrations, reflecting finer sediment texture and possible point sources of pollutants. The study indicates that contaminated sediments have been accumulating on the floodplain and in the backwater ponds for some time and, given present conditions, are likely to continue to do so. In general, the channel area does not represent a significant storage area for contaminated sediments. Further research into Humber River sediment quality is needed to monitor future changes in sediment quality and to pinpoint pollutant sources.

REGIONAL GEOCHEMICAL STRATIFICATION OF SHALLOW GROUNDWATERS RESULTING FROM CATCHMENT URBANIZATION

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Key words: Groundwater, Impact of Urbanization, Contaminant Migration.

ABSTRACT

Contact springs along the Scarborough Bluffs of eastern Metropolitan Toronto provide an ideal opportunity for studying the impact of urban development on shallow groundwater quality. Occupying 12 km of Lake Ontario shoreline, the Scarborough Bluffs represent an important discharge zone for a series of minor aquifers defined within the multi-layer sequence of tills, deltaic sands, and glacio-lacustrine diamicts. Within these deposits, a shallow aquifer system is recharged locally through areas which have recently been transformed from rural pasture to well populated commercial, industrial and residential areas. The deeper aquifer units form part of a regional flow system and are recharged primarily in rural parts of the extensive groundwater catchment.

A major ion, minor ion, trace metal and environmental isotope study of the spring waters reveals major differences in chemical character between the two systems. Groundwaters from the deeper aquifers are low in total dissolved solids and show many similarities to uncontaminated, low tritium and chemically mature waters from deep aquifers in the Duffin Creek-Rouge River drainage basins to the north and east of Metropolitan Toronto. By comparison, the shallow groundwaters reveal the effects of urban development and consistently display elevated concentrations of Ca, Na, NO_3 and Cl with average values of 155, 95, 35, and 200 mg/L respectively. These compare with average values of 70, 10, 5 and 10 mg/L respectively in the deeper waters.

Trace element concentrations of Cr, Co, Cd, Mo, Pb, Mn, Fe, Cu, Ni, Zn, Al and Hg in the spring waters exhibit considerable variability but several high anomalies are noted in the shallow, contaminated waters when compared to background levels determined in rural parts of the groundwater catchment. Since these elements may provide insight to contaminant source origin, complementary investigations are being conducted involving drilling and pore water extraction and analysis at sites where specific types of contamination are suspected. For example, vertical profiles of pore water chemistry from the unsaturated zone adjacent to major salted highways show Cl concentrations up to 14,000 mg/L and provide a range of diagnostic chemical criteria that can be used to confirm suspected road salt contamination in disputed situations.

THE EFFECTS OF TILE DRAINAGE AND OPEN DITCHES ON PEAK FLOWS AND DRY WEATHER FLOWS

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Key words: Agricultural Drainage, Tile Drainage, Hydrologic Simulation.

ABSTRACT

The project is scheduled for a three-year period and has been designed to assess the effects of tile drainage and open ditches on peak flows and dry weather flows with particular application to Ontario. This study involves (I) the development, calibration and testing of a continuous, physically-based, hydrologic simulation model for tile-drained agricultural fields and basins; (II) instrumentation of tile-drained fields in the South Nation River Basin; and (III) statistical analysis of (a) historical data from ditch and tile-drained fields and basins in the South Nation River basin and elsewhere, and (b) simulated discharges generated by the model developed in (I) above, both on a peak flow and a dry weather flow basis.

The project is presently 8 months into year 1 of its three-year schedule. A worldwide literature survey has resulted in the production of an annotated bibliography for the hydrology of agricultural drainage. Over 400 abstracts covering the period 1970-84 have been collected, catalogued and entered in a database using dBASE III. It is available both in hard copy and on IBM-PC compatible disks.

A physically-based hydrologic simulation model for tile-drained agricultural fields has been developed for the simulation of tile drain discharge under single rainfall events. The model is now being tested and calibrated. Instrumentation has been installed in a tile-drained field to collect rainfall and discharge data over the fall of 1985 for analysis during year 2 of the project.

PRE-FEASIBILITY STUDY ON EXPANSION AND UPGRADING OF PORT DOVER SEWAGE TREATMENT PLANT

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Cris Papadopol, Ontario Tree Improvement and Forest Biomass Institute,
Ministry of Natural Resources

Key words: Port Dover, Sewage Treatment, Activated Sludge, Biological Contactors, Aeration Devices, Tree Farm, Lagoons, Effluent.

ABSTRACT

The existing Port Dover Water Pollution Control Plant is a primary plant with phosphorus removal and has been subject to a number of operating problems during the last few years. A study was commissioned to review these problems and evaluate a number of options for expanding and upgrading the plant to provide secondary treatment.

The following options were considered:

- Conventional Activated Sludge
- Rotating Biological Contactors
- Biological Aerated Filters
- Extended Aeration, and
- Tree Farm

Two of the options considered are innovative concepts which have not been used in plants in Canada to date. The first is the biological aerated filter, marketed by Envirotech. It consists of a steel tank filled with fired clay media. Effluent is introduced at the top of the media, the upper section of which accomplishes biological treatment, and the lower section of which acts as a clarifier. The major advantage of this system is the low space requirement, and the fact that no secondary clarifiers are required, thus saving considerable capital cost.

The tree farm design involves storing sewage in a lagoon system and spray irrigating a tree farm with the effluent. In this manner, nutrients in the effluent enhance growth of the trees, and evapotranspiration from the leaf surfaces disposes of all of the effluent produced. This system has the added benefit of producing a valuable by-product, as the fast growing poplar and willow in the tree farm could be harvested as an energy crop every few years.

Capital and operating costs, and benefits of each system are outlined and a present worth analysis covering a 20-year period is performed as part of the analysis.

THE EFFECTS OF WASTEWATER QUALITY ON ULTRAVIOLET LIGHT DISINFECTION

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Key words: Wastewater Quality, Sewage Treatment, Disinfection, Ultraviolet Light Irradiation.

ABSTRACT

Although the ultraviolet light irradiation of treated wastewater has been accepted as a disinfection method, many of the effects of wastewater quality on this process have not been studied at the full scale level.

A full scale gravity flow UV system was placed in the effluent channel of a conventional secondary wastewater treatment plant. The system consisted of a series of modules forming two separate rectangular matrices of UV lamps.

Disinfection is a function of the intensity of UV light and the time of irradiation. The intensity is determined by the lamp output and the UV transmission of the effluent. A UV absorbing compound will be added to the effluent to determine the effect of intensity on disinfection efficiency before and after photoreactivation and will also determine when the UV lamps should be replaced. These experiments will verify that the UV sensor responds linearily to UV transmission. The response of the sensor will then be verified by using the various mathematical models which predict UV intensity and dosage.

The effect of suspended solids in primary and secondary solids may have the most significant effect on the efficiency of disinfection due to the protection of bacteria from UV light. Varying amounts of the three effluents will be mixed with high quality secondary effluent to determine the bacterial reductions before and after photoreactivation. These experiments will be repeated at the mid-point and end point of lamp life to establish the effective lamplife for different qualities of wastewater.

Photoreactivation accounts for the greatest increase in bacterial numbers after UV disinfection. The effect of UV transmission and/or suspended solids on this phenomenon will be studied. The irradiated bacteria will be exposed to various stream conditions and sunlight while they are in glass bottles and an irradiated tracer organism will be exposed to the sunlight and the receiving stream at the same time.

This study will determine whether a correlation exists between E. coli or bacteriophage and the pathogens which may remain in the UV disinfected wastewater. Bacteriophage can be enumerated in as little as four hours and this would serve as a rapid indicator of UV disinfection.

The current mathematical models' ability to predict the dosages within this UV reactor will be compared to actual bacterial reductions to develop design criteria for the UV reactor and various wastewaters.

THE TECHNICAL AND ECONOMIC FEASIBILITY OF RETROFITTING EXISTING MUNICIPAL TREATMENT PLANTS IN CANADA FOR BIOLOGICAL PHOSPHORUS REMOVAL

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Key words: Sewage Treatment, Phosphorus Removal, Activated Sludge.

ABSTRACT

The technical and economic feasibility of retrofitting existing wastewater treatment plants in Canada for biological phosphorus removal was evaluated, with the objective of establishing the type and size of facilities which would be most amenable to implementation of these technologies. The cost analyses were based on model treatment plants having idealized configurations representative of standard design practices. Effluent total phosphorus limits of 1.0 mg/l and 0.3 mg/l were imposed on the processes for the purposes of the cost comparison.

The technical review demonstrated that the four biological phosphorus removal (EBPR) processes evaluated - Bardenpho, UCT, A/O and Phostrip - were capable of producing a final effluent containing between 1.0 and 2.0 mg/l total phosphorus. To consistently achieve effluent phosphorus limits of less than 1.0 mg/l, EBPR processes require some combination of effluent filtration and/or supplemental chemical addition. Further, it was found that ideally, EBPR and chemical phosphorus precipitation processes should be considered to be complimentary processes which should be applied simultaneously to optimize performance and minimize the costs of achieving phosphorus control.

EBPR processes typically involved higher capital investment than chemical precipitation in retrofit situations. However, in conventional activated sludge plant retrofits at a hydraulic capacity of 36.4 Ml/d, the annual O & M costs of all EBPR options with the exception of Phostrip were lower than the O & M costs of chemical precipitation. Financing the higher capital expenditures associated with EBPR processes resulted in generally higher total annual costs for these processes than for chemical precipitation. Only A/O was more cost-effective than chemical precipitation based on total annual costs in any of the retrofit situations evaluated.

In new facilities, conventional activated sludge plants incorporating simultaneous chemical precipitation for phosphorus removal were more cost-effective based on total annual costs than all EBPR processes except A/O. On the basis of annual O & M costs, A/O was generally more cost-effective than the conventional plant, and when a 0.3 mg/l effluent total phosphorus limit was imposed, all EBPR processes except Phostrip had lower annual O & M costs than the conventional plant at a hydraulic flow of 13.6 Ml/d or more.

Conventional activated sludge plants of hydraulic capacity in excess of approximately 14 Ml/d were found to be most amenable to EBPR process retrofits based on the economic evaluation. However, factors such as the existing effluent nutrient limits imposed on WPCPs, the design of existing facilities and the characteristics of wastewaters in Canada combine to limit the number of candidates for retrofit of EBPR technologies. Circumstances which would lead to more widespread implementation of EBPR processes include the imposition of more stringent phosphorus and nitrogen removal requirements, major increases in chemical costs and the development of a greater level of confidence in the performance of EBPR processes.

THE ASSESSMENT OF A POINT SOURCE DISCHARGE OF SUSPECTED MUTAGENIC AND CARCINOGENIC CONTAMINANTS: AN EPIDEMIOLOGICAL APPROACH

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Key words: Mutagenicity, Carcinogenicity, Genotoxicity, Epidemiology, Neoplasia, Fish, Hamilton Harbour.

ABSTRACT

This study was undertaken to correlate genotoxicity with variations in the incidence of neoplasia in wild fish populations. The frequency of genotoxic lesions in adults and embryos has yet to be determined. The frequencies of grossly visible "tumours" are reported for White suckers (Catostomus commersoni) from Lake Simcoe and Hamilton Harbour, as well as Brown bullheads (Ictalurus nebulosus) and Carp (Cyprinus carpio) from Long Point Bay and Hamilton Harbour.

White suckers had lip and skin tumours, as well as hyperplastic skin. A smaller number of liver and other tumours was also present. Fish from Hamilton Harbour had a 58.3% incidence of external lesions, versus 29% in the fish from Lake Simcoe. 14% of the fish from Hamilton Harbour had liver "lumps", 25% lipid changes, and 6.3% intestinal bumps, the fish from Lake Simcoe having frequencies of 21, 7, and 11.6% respectively.

Gonadal tumours were present in 4/5 of the carp/goldfish hybrids from Hamilton Harbour, versus 18/35 from Long Point. No other abnormalities were noted in these fish.

Bullheads possessed both external and liver abnormalities. External growths were present in 14% of the fish from Long Point, versus 48% in the fish from Hamilton Harbour. The only difference internally was a 7% frequency of liver lumps in fish from Hamilton Harbour, while none were present in the fish from Long Point.

Histological confirmation of this data is necessary before any valid conclusions can be made; however, a hypothesis that the fish from Hamilton Harbour are affected by carcinogenic contaminants appears to be reasonable, possibly in association with some other as yet undetermined factors. It remains to be seen whether such observations are of value in predicting the impact of carcinogenic/genotoxic chemicals on feral fish populations.

DEVELOPMENT OF PREDICTIVE ORGANIC CONTAMINANT STRUCTURE-PROPERTY-TOXICITY RELATIONSHIPS FOR AQUATIC ORGANISMS

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Key words: Toxicity, Organics, Aquatic Organisms, Hazardous Contaminants.

ABSTRACT

Aquatic ecosystems and water supplies are exposed to a large number of organic contaminants. Traditional chemical-by-chemical toxicity testing methods are often too slow and expensive to permit all chemicals to be tested. Thus there is an incentive to estimate or predict toxicity from chemical structure using Quantitative Structure Activity Relationships (QSARS).

In this study, acute lethal toxicity tests are being conducted with two small crustaceans, Daphnia Magna and Artemia, and the results are correlated with the chemicals, properties and structure. The chemicals studied include PCBs, chlorophenols, chlorobenzenes, hydrocarbons, and series of nitrogen and sulfur heterocyclic aromatics and polynuclear aromatic hydrocarbons.

The results obtained indicate that the acute toxicity of non-polar organics is primarily controlled by the organism-water partitioning characteristics of the chemical, which is a reflection of aqueous solubility. Mathematical descriptions of this partitioning-toxicity phenomenon are being developed which, it is hoped, will find application to the prediction of the toxicity of various chemicals.

In a complementary study, the photo-induced toxicity of anthracene to Daphnia has been investigated. The results indicate that the primary toxicant is an active (probably free radical) species formed in or on the organism.

THE SIGNIFICANCE OF NEOPLASIA IN FISH POPULATIONS

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Key words: Neoplasia, Fish, Fish Cancer.

ABSTRACT

Our primary goal is to undertake an initial review of environmentally associated cancers in wild fish populations, and to review the evidence that such neoplasms are causally linked to environmental pollutants. Specifically, we wish to determine the extent to which alternative genetic and infectious causes have been considered. We also plan to consider why many other species of fish exposed to the same polluted environment do not exhibit cancers to the extent seen in those affected fish which receive most investigative attention. Other goals are to characterize early precancerous tissue pathology in target species and to determine the biochemical basis of the high susceptibility to liver tumors in some fresh water fish.

EPIDEMIOLOGICAL STUDY OF DISEASE INCIDENCE AND RECREATIONAL WATER QUALITY AT SELECTED CONSERVATION AREAS IN SOUTHERN ONTARIO

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Key words: Epidemiology, Water Quality, Bacterial Pollution, Ontario Beaches.

ABSTRACT

Results of two separate prospective epidemiological surveys at Ontario beaches have shown that morbidity rates are higher among swimmers than among non-swimmers. Swimmers have been shown to experience respiratory ailments most frequently followed by gastrointestinal, eye, ear, skin, and allergenic symptoms.

Concomitant with the epidemiological surveys, water samples were collected at the beaches and analyzed for total staphylococci, heterotrophic plate count, fecal coliforms, Escherichia coli, fecal streptococci, enterococci and Pseudomonas aeruginosa. In all investigations of this nature carried out thus far, correlations between bacterial levels and incidence of illness among swimmers and non-swimmers have been calculated for single organisms only. For example, on our first survey, morbidity among swimmers was shown to be related to staphylococcal counts ($p < 0.001$), to fecal coliform levels ($p < 0.001$) and to fecal streptococcal counts ($p < 0.016$). In this study, combinations of organisms such as E. coli, total staphylococci, and P. aeruginosa will be incorporated into the multiple regression analysis in various mathematical combinations, to determine if multiple indicators will be more appropriate as water quality parameters. Computer analyses are currently being carried out on the data.

FINGERPRINTING THE TORONTO WATERFRONT: A METHOD FOR DETERMINING THE SOURCES OF BACTERIAL POLLUTANTS

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Key words: Ontario Beaches, Lake Ontario, Fecal Contamination.

ABSTRACT

Utilizing restriction endonucleases, a method of "gene fingerprinting" has been devised. As a molecular epidemiologic tool, the method has important applications in establishing specific epidemiological criteria such as defining the sources and routes of transmission of infectious agents.

We have applied the method to outstanding questions related to bacterial pollution at the Toronto waterfront. Using total DNA extracted from Streptococcal organisms isolated from the feces of different animals, humans, water and sediments, we have attempted to correlate and match the gene fingerprints from the different sources. In this manner, we have attempted to establish the sources of, and thus the major contributors to, the overall bacterial pollution prevalent at the waterfront.

At present, the comparison and evaluation of differences and similarities in the hundreds of gene fingerprints studied to date has been performed manually by the investigators. We have tested a number of densitometric devices but their resolution capabilities are insufficient for distinguishing the multiple banding patterns obtained by gene fingerprinting. An alternative method has been studied which utilizes a system for automated computer-assisted analysis of gene fingerprinting data. We will describe a program that allows one to use a small computer equipped with a graphics tablet to scan a gene fingerprint by either wet-gel UV-illumination or white light illumination. The fingerprints are stored in a form in which they can be used later to compile similarities and differences as they relate to the different sources of the pollution.

Our manual results to date have indicated that gene fingerprinting is an extremely powerful tool that is only hampered by the time it takes to match and compare volumes of data over time. For example, geese contain many unique strains of fecal Streptococcal organisms, as determined by their unique gene fingerprints, although there are several "families" of these organisms which are extremely common among the geese populations. Furthermore, several of these common families are also present in water and sediment samples collected in and around the Western beaches area, suggesting that geese contribute significantly to the overall prevailing bacterial pollution. We are also developing DNA probes specific to the fecal Streptococcal organisms isolated from both human and non-human sources in order to provide a more sensitive, specific and rapid means of tracing sources and to quantitatively determine the total contribution of each source to the overall bacterial pollution present at the Toronto waterfront.

VALIDATION AND A POSSIBLE RE-ASSESSMENT OF CLAM CAGING EXPERIMENTS USING ELLIPTIO COMPLANATUS AS BIOMONITORS FOR TOXIC CONTAMINANTS IN WATER

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Key words: Clams, Biomonitoring, Toxic Contaminants, Bioaccumulation, Great Lakes.

ABSTRACT

A set of experiments was undertaken to examine the effects of cage design on the uptake and purging of toxic contaminants by the freshwater mussel Elliptio complanatus. Three types of enclosure apparatus were used to obtain comparisons of bioaccumulation rates at four Lake St. Clair sites, representing a wide range of toxicant levels (with respect to PCBs, OCS, lead and cadmium). The enclosures included wire cages (in standard use by MOE), circular corrals 1.25 m in diameter (each containing 5 clams) and clams, tethered to a transect with monofilament line. Another freshwater mussel, Lampsitis radiata siliquoidea, which is native to all Great Lakes, was compared to Elliptio by replicating each treatment.

The study clams were obtained from Balsam Lake, Rosedale, Ontario (for Elliptio) and Anchor Bay, Lake St. Clair (for Lampsilis). Clams and sediment samples were taken from each location where enclosures were deployed and from clam collection sites to determine background levels. The effect of sediment on toxicant uptake was examined using purified sand in half of the corrals.

The first set of clams was deployed in early June and recovered after a 46-day period. A second set of animals was deployed during the first week of September to make possible the examination of seasonal variation in contaminant uptake. Other aspects under study include sexual variation and the effect of varying exposure time on bioaccumulation of toxic contaminants by unionid molluscs.

REVISED MONITORING SCHEME FOR PERSISTENT AND TOXIC ORGANICS IN GREAT LAKES SPORTS FISH

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and
G.A.V. Rees and G. Crawford, Ontario Ministry of the Environment

Key words: Toxic Organics, Great Lakes, Fish Analysis, Persistent Organics.

ABSTRACT

A monitoring program for the identification and quantification of semi-volatile, persistent and toxic organic contaminants has been undertaken on selected samples of sports fish from the Great Lakes. The analytical methodology employed cold acid dissolution of the tissue, partition of the organics into solvent, followed by Gel Permeation Chromatography for the removal of lipid materials, and finally, full scan gas chromatographic/mass spectrometric (GC/MS) analysis. In addition to this analysis, negative ion chemical ionization (NCI) GC/MS analyses were also performed to provide enhanced sensitivity for halogenated organics below the ~50 ng/g (ppb) detection limit achievable by full scan electron impact GC/MS.

Samples of various fish species were collected from near-shore and open-lake areas of Lake Ontario, Lake Erie, Lake St. Clair, Lake Huron and Lake Superior. Summary data will be reported for the fifty samples analyzed and specific conclusions and recommendations based upon these data will be presented.

DEVELOPMENT OF A COST EFFECTIVE PROTOCOL FOR ROUTINE ANALYSIS OF TRACE ORGANIC CONTAMINANTS IN MUNICIPAL WPCP RAW SEWAGES AND FINAL EFFLUENTS

John Martin, Cecilia Chan and Dale Sutherland, Mann Testing Laboratories Ltd., and Gerry Rees and Tony Ho, Ministry of the Environment

Key words: Trace Organics, Sewage, Analytical Method, Effluent, Wastewater.

ABSTRACT

A novel analytical method has been developed for routine monitoring of trace organics in municipal wastewater. The prime objective of this work was to design a highly efficient protocol to ensure maximum sample throughput and to provide the required accuracy, sensitivity and reliability for such analyses.

Two methods were proposed and investigated in this study, which included the thermal stripping technique and the simultaneous in-situ acetylation and extraction method for bases, neutrals and phenolic compounds. The extraction performance was based on the results from a target list of chemical parameters chosen to represent various classes of compounds using organic free water, WPCP raw sewage and final effluents as test substrates.

The in-situ acetylation and extraction method was selected after preliminary investigation due to its ease of sample processing. The recoveries of the parameters and their corresponding coefficient of variation proved that the overall protocol was comparable, or in most cases, better than the EPA method 625. Some of the advantages of this method are:

- Rapid one-step extraction and derivatization
- No clean-up required
- Better recoveries for phenolic compounds and organochlorine pesticides
- Reduced fatty acid interference
- Better chromatography for phenolic and amino compounds.

All analyses were performed using a gas chromatograph coupled with a mass selective detector. Customized software was developed to generate multiple reports from a single analysis and to improve the autosequencing flexibility in sample processing and interpretation.

ANALYSIS OF CHEMICALS USED AT WATER TREATMENT PLANTS

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Key words: Organic Analysis, Water Treatment Chemicals, GC-MS.

ABSTRACT

The objective of this study was to develop analytical methodology for the isolation and identification of trace organic contaminants present in inorganic water treatment chemicals. This work included the development of extraction techniques in which the organic compounds are separated from the largely inorganic sample matrix. Further separation and identification of the organic compounds in the final extracts was carried out using combined gas chromatographic/mass spectrometric techniques.

A wide variety of the chemicals most commonly used in the water treatment process were studied. These chemicals are used in processes such as coagulation, pH adjustment, corrosion control, water softening, and fluoridation. The chemicals studied were classified into two distinct groups, each of which required a different extraction procedure. Solid samples were extracted using Soxhlet extraction techniques, while sample preparation for the aqueous solutions involved liquid-liquid extraction with a suitable organic solvent.

Compound identifications were made using GC/MS techniques in which two ionization modes were employed. Electron impact ionization was used for obtaining structural information, while chemical ionization using methane as the reagent gas was used for molecular weight determination.

The organic contaminants which were identified consisted of compounds such as: straight-chain alcohols, carboxylic acids, and alkenes; aliphatic and phthalate esters; cyclic ketones, alcohols, and alkenes; phenolic compounds and other substituted aromatic compounds; and compounds containing nitrogen and/or sulphur. The majority of these contaminants are simple hydrocarbons, while chlorinated species are virtually absent with only three identified. The total organic content in the chemicals studied was found to range between 0.01 and 300 ppm, with the majority of these samples containing less than 10 ppm of organic contaminants.

BIOACCUMULATION OF MERCURY BY YELLOW PERCH

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Key words: Bioaccumulation, Mercury, Yellow Perch, Fish.

ABSTRACT

The objective of the project is to model the bioaccumulation of mercury in young-of-the-year (yoy) yellow perch. Three Precambrian Shield lakes in the Dorset area are being sampled for biological and mercury accumulation data for yoy perch throughout their first year.

The bioaccumulation of mercury is a function of growth, respiration and consumption of fish as well as a function of waterborne and prey mercury concentrations. The biological variables will be modeled using an energetics approach. The model developed by Kitchell et al (1977) and modified for yoy perch by Post and McQueen (ms) will be applied. The mercury kinetics as determined by Norstrom et al (1976) will be integrated with the energetics model to calculate an expected body burden given consumption and respiration rates and mercury concentrations in prey and water. Intra- and inter-lake variation in observed body burdens will be explained as a function of the above rates and concentrations. Fish mercury body burdens are being determined presently at I.E.C. Beak Analytical Laboratory, and water and prey mercury concentrations are being determined by Dr. Greg Mierlie (OMOE, Dorset).

The May to October 1985 collections have been successfully completed, and the last collection is scheduled for May 1986. Once the mercury data has been received from the two laboratories, a preliminary run of the model can be completed, the final run to be completed when the data from the May 1986 collection has been received. Report completion is expected by early summer 1986.

BIOLOGICAL INDICATOR SYSTEM TO IDENTIFY GENOTOXICITY OF IN-PLACE POLLUTANTS

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Key words: Toxicity, Neoplasia, Aquatic Organisms, Molluscs, Sediment Contamination, Uranium Refinery, Port Hope.

ABSTRACT

Although less studied than fish, benthic macroinvertebrates would be ideal organisms for monitoring genotoxicants in terms of an *in vivo* neoplasia response (Black, 1984). The organisms are sedentary and intimately associated with the bottom sediments which act as contaminant 'sinks'. For the marine environment, most studies involve the occurrence of neoplasms in filter-feeding molluscs. For the freshwater environment, the majority of studies have looked at the occurrence of deformities in Chironomidae.

The incidence of deformed chironomid larvae at a number of locations in the Great Lakes has been reported (e.g. Brinkhurst *et al*, 1968; Boscor *et al*, 1974; Hare and Carter, 1976; Warwick, 1980; Crowther and Luoma, 1984; Kreiger, 1984). Increased frequencies of deformities are tentatively attributed to industrial and/or agricultural pollution. However, an absolute relationship between specific persistent toxic substances and frequency of deformities has not yet been established (Hamilton and Saether, 1971).

BEAK (1985) recently completed a study charaterizing the sedimentary environment of Port Hope Harbour, which has been contaminated by various urban, agricultural and industrial activities, including the operation of a radium recovery plant from 1933 to 1952, and a uranium refinery since 1955. Sediment contamination has been studied since 1967 by the Environmental Protection Service, the Ontario Water Resources Commission and the Ontario Ministry of the Environment. A prior study of harbour benthos in relation to sediment contamination was conducted by Cook and Veal (1968). The BEAK (1985) study was designed to detect any changes that may have taken place since that time, and to assess the current degree and biological impact of sediment contamination.

Cook and Veal (1968) noted that most *Chironomus* at a station near the uranium refinery discharge in the turning basin of the harbour had deformed labial plates. Based on examination of 48 specimens of *Chironomus* collected by BEAK in 1984 from the turning basin and outer harbour, 73% showed deformities. Of the 48 *Chironomus* specimens, forty were taken from the turning basin, seven from the outer harbour and one from the lower Ganaraska River. Among these, 83% (33 of 40) from the highly contaminated turning basin were deformed, while only 14% (1 of 7) from the less contaminated outer harbour were deformed. A single specimen collected in the Ganaraska River was also deformed. Extremely high levels of radionuclides, fluoride, arsenic and nickel in turning basin sediments are suspected as potential causes of the high incidence of deformities in the *Chironomus* populations. A preliminary examination of other chironomid species, most notably *Procladius* and *Dicrotendipes*, demonstrated that deformities also occurred in these groups.

A more intensive sampling of the harbour has been undertaken to provide sufficient numbers of chironomid larvae to permit statistical analysis of the relationship of deformity frequency to site-specific contaminant and radiochemical data. The results of this analysis will be discussed, and recommendations for laboratory validation will be provided.

HUMBER RIVER/BLACK CREEK: DETAILED BACTERIOLOGICAL WATER QUALITY STUDY EXAMINING THE IMPACT OF SEDIMENT AND SURVIVAL TIMES

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Key words: Humber River, Sediment, Bacteria, Water Quality, Black Creek.

ABSTRACT

Bacterial transfer between the water column and the sediment of the Humber River/Black Creek was studied to determine the relative bacterial loading contribution made by resuspension of the sediment, and to observe the extent of sediment transport between sources. Survival times of indicator bacteria in the river were also studied to assess bacterial response to the river environment, and to predict bacterial loadings from distant point sources.

The bacterial contribution from sediment was measured during: (1) dry weather (before and after sediment agitation); (2) wet weather; and (3) a variety of flow conditions at different sample sites impacted upon by storm sewers and combined sewers. Preliminary data on the effects of changing weather and flow conditions on sediment resuspension and transport and the relative effect of different source inputs were obtained. It was found that during dry weather, at locations where point sources contribute high bacterial loadings (for example, storm sewer effluents with high bacterial counts), the samples taken after sediment agitation at source and downstream sites had higher fecal coliform levels than samples collected before agitation. During wet weather or other times of augmented flow conditions, detection of point sources in the river was obscured by upstream contamination from other sources and from sediment resuspension.

The survival times of indicator bacteria in the Humber River appeared to depend upon the bacterial species and upon site specific factors such as temperature flow, and nutrient and/or chemical pollutant input. In general, *E. coli* and enterococci exhibited rapid die-off with enterococci surviving somewhat longer at sites such as storm sewers where the nutrient input might have been higher. The results indicated that within the enterococcus group, *Streptococcus faecium* may survive longer than *S. faecalis*; however, additional survival rate studies are needed to confirm this result.

It is anticipated that an intensive analysis of the data will help develop models of bacterial response and sediment transport under varying conditions and lead to a more reliable management strategy.

DEGRADATION OF ORGANIC CONTAMINANTS BY ANAEROBIC BACTERIA IN LAKE ONTARIO SEDIMENTS

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Key words: Organics, Sediment, Lake Ontario, Anaerobic Bacteria, Contaminant Degradation.

ABSTRACT

Anaerobic bacteria in sediments have the potential to degrade at least some of the xenobiotics impacting Lake Ontario sediments. Sediment samples are removed by dredging, and slurries are prepared in mineral salts base under reduced conditions using an anaerobic cabinet. The rate of turnover of relatively simple, unlabelled toxic organics (e.g. 3-chlorobenzoic acid) by anaerobes in such a slurry can be assayed by gas chromatography (GC). In further experiments using undisturbed water-sediment "eco-cores" (taken with a Jenkin mud-surface sampler), the radiolabelled toxicant(s) is injected into the sediment. Subsequently, intermediate metabolites and gaseous end-products are monitored by thin-layer chromatography (TLC) and GC, respectively.

Because of the possible presence of organic contaminants at concentrations which could inhibit bacterial activity, it may be necessary to sample several sites in order to obtain suitable sediment samples for slurry and "eco-core" experiments.

IN SITU ASSESSMENT OF MIXED COPPER AND ZINC IMPACTS ON WHITE SUCKER (CATASTOMUS COMMERSONI) POPULATIONS IN SEVERAL NORTHERN ONTARIO LAKES: AN EVALUATION OF THE ENVIRONMENTAL HEALTH ASSESSMENT APPROACH TO VALIDATING WATER QUALITY CRITERIA

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Key words: Toxicity, Metal Contamination, Fish, White Sucker, Water Quality Criteria, Environmental Health Assessment, Northern Ontario.

ABSTRACT

This study represents an integrated field-laboratory program designed to determine the impacts of metal contamination on the white sucker populations of several lakes in the Manitouwadge district of Ontario. The ultimate aim of the project is to assess metal effects in terms of reproductive capacity and survival of larval fish. This work develops a model of integrated in situ methods for the assessment of toxicant impacts on wild fish populations. In addition to the fertilization and survival experiments, the study is following seasonal changes in the histological evaluation of health status and gonadal development, and measured levels of serum steroids. Suckers are being examined from single lakes showing either elevated mixed levels of waterborne copper and zinc or moderate levels of these metals, and from a control lake with background metal levels. Preliminary analysis of the samples collected in the first collection period suggests that the metal-exposed fish are significantly shorter and lighter than the control fish, although they were of a comparable age. Furthermore, sparse data collected at the end of the 1985 spawning season suggests several other changes in metal-exposed fish, including an increased larval deformity rate, smaller egg size and increased fecundity relative to control fish. Further collections will quantify the differences and investigate possible mechanisms to explain the changes, including examination of blood hormone profiles, tissued pathological evidence and local acclimation to elevated metal levels. The project is gearing towards large-scale field-testing of a simple, quantitative, in situ reproductive efficiency model during the 1986 spawning season.

FRESHWATER CLAMS AS MONITORS OF THE NEARSHORE ENVIRONMENT

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Key words: Biomonitoring, Clams, Nearshore Environment, Lake Erie.

ABSTRACT

The response of freshwater clams to environmental variation (both natural and human-induced) at the community, population (genetic), and organismal levels are being studied. Our results and the further research they have stimulated are summarized below.

- The structure of fingernail clam communities is related to wind-induced turbulence. More species occur in the more exposed, sandy areas of Inner Long Point Bay, Lake Erie, than in the mucky areas of the bay.

- The growth rate and shell morphometry of Lampsilis radiata, a freshwater mussel, are also related to turbulence. Smaller, more obese clams are found in the muckier areas of the bay whereas larger, more streamlined clams are found in the sandier areas. A transplant experiment suggested that this relationship may be due to genetic differences between clams from the muck and those from the sand, and preliminary electrophoretic data support this interpretation. An artificial pond experiment is being carried out to see if this species exhibits a preference for mucky or sandy habitats, and if this preference depends on what type of habitat the clams come from. Laboratory rearing of the clams is being undertaken to determine the heritability of shell growth rate and form.

- The relationship between the accumulation of trace metals in another freshwater mussel (Elliptio complanata) and the alkalinity of the water column is being similarly studied. Field observations from Central Ontario lakes are currently being analyzed, and transplant experiments have commenced.

- Several analytical techniques have been explored in an effort to measure temporal changes in the concentration of both organic and trace metal contaminants as recorded in the bivalve shell. These have included electron probe analysis, scanning ion microprobe, stable carbon and oxygen isotope ratios, and atomic absorption spectroscopy. The lack of success with these techniques will be discussed.

FEASIBILITY OF PLANT HARVESTING IN WATER QUALITY AMELIORATION AND PHOSPHORUS MANAGEMENT IN SHALLOW IMPOUNDMENT

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Key words: Aquatic Plant Harvesting, Water Quality, Phosphorus Control, Nitrogen Control, Orangeville Reservoir, Credit River.

ABSTRACT

In a survey of over 50 Southern Ontario reservoirs managed by conservation authorities, eutrophication, as indicated by aquatic weed proliferation and/or algal blooms, was reported as a major management problem for over 80% of the impoundments. Many of the responses reported phosphorus concentrations in excess of MOE guidelines.

Aquatic plant harvesting may represent a simple and relatively low cost method of nutrient management in the Great Lakes Basin. Generally, nutrient loss due to plant removal is insignificant compared to the total nutrient budget in a waterbody, especially in the sediments. However, in shallow ponds and impoundments where macrophyte biomass is high in relation to the total volume of water, long-term harvesting, combined with control of nutrient sources, may remove a sufficient portion of nutrients to significantly improve water quality.

The Orangeville Reservoir, located at the headwaters of the Credit River, is typical of many Southern Ontario reservoirs. It is highly eutrophic and contains heavy growth of aquatic macrophytes (Myriophyllum spp.). The Credit Valley Conservation Authority desires to maintain or improve water quality in the reservoir. In 1984, a mechanical plant harvesting program was initiated. In this study, the harvesting program and its potential for water quality improvement, at Orangeville Reservoir and in other similar impoundments in Southern Ontario, have been evaluated.

Based on a simplified input-output budget for total phosphorus and total nitrogen, the Orangeville Reservoir was found to act as a nutrient sink rather than a source to downstream waters. The major storage compartment for both nitrogen and phosphorus was the highly organic sediments. Net phosphorus retention by aquatic vegetation was small, and therefore it is unlikely that plant harvesting will significantly improve phosphorus concentrations in the water. This condition was attributed to the fact that most of the phosphorus used by plants is obtained via the sediments. There was no indication of phosphorus release during winter die-off, suggesting that phosphorus tied up in the plants is returned to the sediments, thus completing the internal cycle.

On the other hand, up to 55% of total nitrogen requirements of plants appeared to be met from the water column. Thus, harvesting represents a potentially effective method of nitrogen control. The need for nitrogen control in the upper Credit River has been recognized by the MOE and the Town of Orangeville in the incorporation of a denitrification unit in the Orangeville Water Pollution Control Plant. From the perspective of the lower Great Lakes basin, multi-year studies show that loadings of inorganic nitrogen compounds are increasing.

The monitoring program has been expanded and will be continued through at least one full growing season to permit refinement of the nutrient budget and to determine harvesting optimality in biomass and nutrient removal.

DIFFERENTIATION OF FECAL COLIFORMS AND FECAL STREPTOCOCCI AND VERIFICATION OF NEWER TESTS TO DETERMINE HUMAN AND NON-HUMAN FECES

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Key words: Fecal Contamination, Humber River, Black Creek.

ABSTRACT

A bacteriological study of the Humber River Basin within the Metropolitan Toronto boundaries was conducted during the fall of 1983 (Gore and Storey), to assess the bacteriological water quality of the Humber River and Black Creek and to identify the origin of fecal contamination in both watercourses (i.e. human or non-human). Two newly developed media for the isolation and enumeration of E. coli (m-TEC IG with indoxyl-B-D-glucoside) and enterococci (m-ME with indoxyl-B-D-glucoside) (Dufour 1983) were tested under field conditions during the study.

The specificity of the new media was assessed using data pertaining to the isolation and identification of 3683 bacterial isolates taken from samples analyzed during the study. Overall, the m-TEC IG medium provided a good estimation of the concentration of E. coli. There was, however, a tendency for a slight overestimation especially during wet weather conditions. The m-ME medium appeared to be acceptable for the enumeration of enterococci during both wet and dry weather events, but gave a slight underestimation of the actual concentration of enterococci.

Information on the bacterial populations in the Humber River and Black Creek was studied to determine the original sources of fecal contamination. The data yielded only a limited number of conclusions due to the fact that only six sampling stations along the entire river course were assessed (four during wet weather). This approach to evaluating potential sources of fecal material would be more productive if used in conjunction with studies of single inputs, e.g. storm sewers, and a more selective sampling program.

INSTRUMENTAL NEUTRON ACTIVATION (INAA), INDUCTIVELY COUPLED PLASMA/MASS SPECTROMETRIC (ICP/MS) AND METAL SPECIATION (SPEC) ANALYSIS

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Key words: Multielement Analysis, Neutron Activitation Analysis, ICP-MS, Metal Speciation, Metals, Analytical Methods.

ABSTRACT

INAA techniques have been initially optimized for the analysis of ten elements (Al, Br, Ca, Cl, Cu, I, Mg, Mn, Na, V) in precipitation and surface water with detection limits at a few ng/mL. The elemental suite has also been extended to the analysis of As, Ba, Mo, Sr and K. Quality control is maintained by analyzing NBS reference water standards. No chemical work-up is required, making this technique efficient and cost-effective for these metals. INAA has recently been used to determine different Al "species" after they have been separated by different techniques.

ICP/MS, a new technique, combines the sample inlet systems of ICP with a quadrapole mass spectrometer. Thus both concentration and isotopic ratios of elements can be measured. A practical detection limit of about 10 ng/ml is typically achieved. Quantitative analysis can be achieved by comparison of the signal to a working curve, by standard addition and by isotopic dilution. Because of the lack of long-term machine stability, we have chosen the isotopic dilution method, which, however, requires an extra step. $^{208}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$ can be measured quite rapidly with a precision of $\pm$ 0.8% using a 1 mg/l solution. Preliminary results suggest a similar precision at 0.1 mg/l. The accuracy at this level is $<$ 1% as compared to NBS 981 and 982. Additional comparison against the state-of-the-art thermal ionization mass spectrometer (VG354) with a precision of $<$ 0.01% is used for quality control.

Analysis of Pb isotopic ratios for atmospheric particulate and precipitation samples, as well as selected source material, is under way. Results of this pilot study will be used to define Pb sources and mixing of Pb in the atmosphere.

Metal lability (reactivity) analysis is important when considering potential biological toxicity. Most tests for "speciation" involve partial extraction or reactivity of the metal in an operationally determined mode. Al "speciation" has been given particular attention, and the reactive form has been determined by titration of F against the F electrode response, and from the kinetics of development of fluorescing Al-lumogallion complex. The F test for "reactive" aluminum gives similar results to those from the Al-lumogallion method; both tests are less robust than oxine extraction, which in turn is less robust than ion exchange. Results of round-robbin tests for total Al and "reactive" Al using INAA, fluorescence, F electrode, and lumogallion (McMaster labs) are compared to oxine, graphite furnace atomic absorption spectroscopic, catechol violet, and Chelex extraction techniques of M.O.E. and I.N.R.S.-Eau laboratories.

AN EVALUATION OF THE REPLICATIVE KILLING MUTAGENICITY ASSAY

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Key words: Mutagenicity, Assays, Ames Test.

ABSTRACT

Two bacterial mutagenicity assays, the Replicative Killing (RK) assay and the Ames test, were compared for their ability to discriminate between mutagenic and non-mutagenic chemicals. While the Ames test is internationally recognized, the RK assay has only recently been developed. The Ames assay detects mutagenic activity as revertants of the histidine operon in Salmonella typhimurium; the RK assay detects this activity by measuring inactivation of a temperature inducible cryptic phage in Escherichia coli. Of these two assays, the RK assay should theoretically be the more efficient since it offers a larger DNA target, a greater number of DNA leasons are detectable and chemical toxicity interferences are reduced.

In this study, we employed the shorter version of the RK assay, referred to as the Quantitative Rapid protocol. This version was designed for the screening of chemicals. The RK assay was evaluated using 13 chemicals, including four "standard" mutagenic compounds and nine "reference" compounds considered difficult to distinguish in bacterial mutagenicity tests. Included in the reference compounds were six presumptive carcinogens and three non-carcinogens. The results of the RK assay were compared to a parallel screen of the four standard and six reference compounds using the Ames test.

All of the four standard compounds were mutagenic in the Ames test. The RK assay successfully identified three of these but was unable to detect the mutagenic activity of 2-nitrofluorene.

The results of screening tests for both the Ames test and the RK assay on six reference compounds were consistent. Of these compounds, five were found to be non-mutagenic while one, 2-acetylaminofluorene (2AAF), was mutagenic in both assays. Of the four presumptive carcinogens in this group, only 2AAF was detected as mutagenic in either assay while three, Diethylstilboestrol (DES), o-Toluidine and Phenobarbital (PB) were non-mutagenic. The results of this study do not confirm the previously reported activity of DES and PB in the RK assay. In addition, neither assay detected activity with the non-carcinogen 4-acetylaminofluorene which has been reported mutagenic in bacterial assays.

An additional three reference compounds screened by only the RK assay were found to be non-mutagenic. All three of these compounds have been reported non-mutagenic in bacterial assays, although two of these compounds (Hexamethylphosphoramide and Safrole) are presumed carcinogenic.

From the results of this study, we would conclude that the RK assay, with the protocol used here, offered no additional advantages to the Ames test in screening for mutagenic compounds. Although a thorough evaluation of the assay should include a screen of a wider range of compounds plus an expansion of the RK assay protocol, its advantages over other short-term bacterial mutagenicity assays have not been

PROPOSAL TO DEVELOP THE HELIUM MICROWAVE PLASMA DETECTOR AS A NON GC/MS SCREENING TECHNIQUE

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Key words: Gas Chromatography, GC-MS, Multielement Analysis, Analysis, Volatile Organics, PCBs.

ABSTRACT

Much of this talk will describe the experience that Barringer Magenta Limited has gained in building a helium microwave plasma GC detector. The objective of the work was to develop a universal detector for GC analysis of substances at trace levels in complex matrices.

The system is based on a nine-channel polychromator monitoring the emission from a helium microwave plasma maintained in a Beenakker-type cavity. A gas control unit provided interfacing of the plasma to a Hewlett-Packard 5730 series gas chromatograph. Simultaneous multi-element determination of C, P, Hg, Br, Cl, S and F is achieved with the spectrometer based on a half-metre radius concave holographic grating in a Rowland mounting. The plasma is viewed axially from the open end of the quartz discharge tube. The grating spacing is 1180 lines/mm and the spectral range from 190 to 800 nm is covered in the first order. Wavelength modulation for background correction is achieved by means of a chopper disc and dual entrance slit. An inert "valveless" GC to cavity interface permits venting of the solvent while passing subsequent GC effluent to the cavity. A gas control unit contains the elements necessary to control the gas flow through the interface (including scavenger gas) as well as electronics to control the transfer line temperature. The interface is capable of supporting both packed column and capillary column chromatography.

Measurements of emission intensity across the diameter of the discharge tube indicated that maximum emission intensity for all elements occurred near the central axis of the tube and this position was independent of plasma power and support gas flow rates. Compromise operating conditions resulted in detection limits of between 1 and 30 $pg\text{-}sec^{-1}$ for the elements studied. Attempts to eliminate background levels of nitrogen and oxygen through special gas purification steps and modification to the discharge tube were only partially successful.

The work done at Barringer, as well as results reported in the literature, have indicated that the helium microwave plasma detector shows great potential as a simultaneous multi-element detector. In the current project, this type of instrument will be developed as a detector for volatile organic contaminants as well as chlorinated pesticides and PCBs in water.

THE EVALUATION AND APPLICATION OF PULSED NUCLEAR MAGNETIC RESONANCE IN THE ANALYSIS OF ENVIRONMENTAL SAMPLES

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Key words: Pulsed NMR, Analysis.

ABSTRACT

In recent years, low resolution pulsed nuclear magnetic resonance (NMR) has been applied to a diverse number of chemical situations, particularly of a quantitative nature. Typical of this diversity of application include the moisture content of food products, the fat content of dairy products, the solid-to-liquid ratio of chocolate, the ratio of bound-to-free water and the oil content of peanut seeds. All analyses are rapid, require little or no sample work-up, and are non-destructive.

The application of this technique to the analysis of environmental samples will be presented. The Bruker Minispec PC 20 NMR spectrometer was used and data will be presented on the analysis of soil samples for moisture and organic analytes. Included will be a description of instrument calibration, the amount of sample required, the sensitivity of the technique, and the effect of sample temperature on the analytical data. Paramagnetic species, routinely present in soils, have a dramatic effect on the NMR signal, and the methodology for analysis under these conditions will be presented.

STUDIES OF METHODOLOGY AND INSTRUMENTAL CAPABILITIES FOR OPTIMUM AND RAPID ANALYSIS OF PCDD AND PCDF COMPOUNDS IN WATER

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Key words: Dioxins, Furans, Water Analysis, Groundwater, Elmira.

ABSTRACT

The suitability of sorbent trapping for the analysis of polychlorodibenzo-p-dioxins (PCDDs) and octachlorodibenzofuran (OCDF) at the extremely low level important to water analysis using AMBERLITE XAD-2 and XAD-4 macroreticular resins, and XE-340 carbonaceous material has been investigated. XAD-2 and XAD-4 gave better recoveries than XE-340 in spiked recovery studies at 33 parts-per-trillion for 1,2,3,4-TCDD, 1,2,3,4,7-PCDD, 1,2,3,4,7,8-H_6CDD, 1,2,3,4,6,7,8-H_7CDD, OCDD, and OCDF. XAD-2 gave virtually quantitative recoveries for up to 400 ml/min spiked water flow through a 13 cm x 1 cm I.D. column.

A sampling device was designed using a magnetically coupled gear pump, stainless steel tubing, columns containing XAD-2 resin, rotameters and a glass microfiber filter. Water was pumped through the filter before it reached the XAD-2 columns. Sampling of environmental waters showed that the glass microfiber filter used to trap particulate matter was found to preconcentrate the PCDD and PCDF, while anlaysis of the adsorptive columns did not reveal the presence of these compounds. This method may be suitable for a monitoring program but consideration must be given to the sample matrix.

Using our sampling device, two sites were sampled: the Lakeview Water Treatment plant, Toronto, Canada and the Uniroyal Facility in Elmira, Canada. Only OCDD was detected in the Lakeview samples and results obtained from parallel sampling with solvent extraction and filtration combined with sorbent trapping gave levels for the plant influent of 9 parts-per-quadrillion (2 samples) and 10 parts-per-quadrillion (1 sample), respectively. This agreement between the two methods indicates that the technique using a filter is suitable for monitoring low levels of OCDD. The plant effluent did not contain OCDD, therefore the plant removes this contaminant to below detectable levels.

The Elmira Uniroyal Facility groundwater was sampled in duplicate and the PCDD and PCDF compounds were isolated on the filter on both occasions. The levels detected range from several ppq to 179 ppq and the first sample which contained more material on the filter had more PCDD and PCDF than the second sample. Based on the sampling results, the filter traps the particulate matter upon which the PCDD and PCDF are adsorbed.

AUTOMATED CARBON ANALYSIS - A REPLACEMENT FOR BODs?

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Key words: Carbon Analysis, BOD, Organics.

ABSTRACT

This project is designed to test the potential of a relatively new automated carbon analyzer as a replacement for traditional BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) tests. Traditional tests of oxygen consumption such as BOD and COD are lengthy and labour-intensive. With the advent of flow-through, automated carbon analysis, it may be possible to pre-screen samples for high organic carbon concentrations. If there is a reasonable correlation between the level of organic carbon and the BOD of a sample, the automated carbon method may have potential as a fast inexpensive screen for samples requiring the more time-consuming traditional tests.

In the first phase of this project, the operating characteristics of a carbon analyzer which utilizes a persulfate - UV digestion system coupled to an auto sampler will be examined. Precision and accuracy as well as practical operating ranges and detection limits will be determined. Once adequate performance has been ensured, samples from various sewage outfalls will be collected. These samples will be used to determine various carbon fractions (organic, inorganic, purgable, total) as well as BOD. From the relationships between these measurements, it will be possible to determine the value of the automated carbon approach as a fast screen technique.

It is anticipated that the first phase (i.e. performance testing) of the project will be completed by early November. Some of the correlation work will be done by the beginning of December. It is the results of these two phases of the project which will be presented to the Technology Transfer Conference.

THE EFFECT ON THE TISSUES OF YOUNG FISH AND RATS OF EXPOSURE TO Pb, Cd, AND Hg: DEVELOPMENT OF A BIOINDICATOR ASSAY

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Key words: Bioassays, Bioindicator, Toxicity, Metals, Fish, Rats, Exposure, Enzymes.

ABSTRACT

A series of experiments were conducted in which goldfish were exposed in the laboratory to Pb or Hg, separately or in combination, for 3 or 6 weeks. The water was exchanged each week. Yellow perch from several Ontario lakes were also brought to the laboratory for similar testing.

The muscle and liver of the fish were homogenized in a Tris.HCl buffer (Ph 7.6) containing sucrose, Mg acetate and K acetate for preparing the protein synthesizing enzymes. Other samples of the fish muscle and liver were used to prepare homogenates for measuring several glycolytic enzymes and several membrane enzymes.

Pb exposure of 100 or 500 ug/1 for 3 to 6 weeks resulted in statistically significant changes in the activities of liver lactate dehydrogenase and muscle glyceraldehyde-3-phosphate dehydrogenase, while liver membrane enzymes exhibited increased activities. Pb exposure of 5 ug/1 for 20 weeks exerted no effect on the enzyme activities. However, Pb exposures of 25 ug/1 for 6 weeks in combination with 0.25 ug/1 Hg and 0.25 ug/1 Cd resulted in significant decreases in the activities of muscle glycolytic enzymes and increases in liver membrane enzymes.

Similar changes in liver and muscle glycolytic and membrane enzymes were found in fish exposed for 6 weeks to 30 ug/1 Hg alone. Most significantly, the protein synthesis enzymes were decreased markedly in both of these tissues. Preliminary results from the fish from Hg-polluted Ontario lakes indicate similar enzymatic trends.

There is a paucity of information on protein synthesis enzymes and other tissue maintenance enzymes with regard to environmental stress such as heavy metal exposure. Our results point to a method for establishing a bioindicator assay for heavy metals.

ANALYSIS OF DIOXINS AND FURANS IN FISH AND OTHER BIOTA

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Key words: Dioxins, Furans, Fish, Analytical Methods, Liquid Chromatography.

ABSTRACT

A high performance liquid chromatography (HPLC) method was developed for the fractionation of complex organic matrices using a two-step procedure. The HPLC method was originally devised based on work done using a model system which was a solution of standard compounds representative of various compound classes found in fish tissue. This standard solution was made up of compounds such as polychlorinated dibenzo-p-dioxins (PCDD), poychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), chlorinated pesticides, chlorinated aromatics, and aliphatic hydrocarbons. The two-step procedure developed utilized a normal phase HPLC fractionation (using a silica column) followed by a reverse phase cleanup (using a C-18 column). The recoveries of the individual HPLC cleanup procedures, based on the model system, were quite high for most compounds (an average recovery greater than 80 per cent).

Once the initial method had been developed using the model system, the cleanup procedure was tested with an actual fish extract which had been fortified with a known quantity of the test mixture. The complex organic matrix did not have any effect on the fractionation process because all of the added standards were found to elute in the same fractions as observed when the model system was tested. A non-fortified sample extract was also subjected to the HPLC cleanup and the individual fractions were then analysed by GC using flame ionization detection (FID) and electron capture detection (ECD). Based on the appearance of these chromatograms, reasonable separations were obtained for many different components in the matrix. The individual fractions were then injected, analyzed by GC/EIMS under linear and selected ion monitoring (SIM) modes of operation. This GC/MS data is currently being studied in order to evaluate the effectiveness of the HPLC cleanup procedure and determine what modifications, if any, are necessary.

PART THREE

LIQUID AND SOLID WASTE RESEARCH

HAZARDOUS ORGANIC CHEMICALS IN GROUNDWATER AT ONTARIO LANDFILLS

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Key words: Hazardous Organics, Organics, Groundwater, Landfill.

ABSTRACT

Research in 1984/85 has concentrated on the occurrence and migration of organic contaminants at three landfill sites to determine the hydrogeological, geochemical and microbiological controls on the contaminant distributions. The North Bay and Woolwich plumes occur in stratified sands and the New Borden plume occurs in sandy silts. Emphasis has been placed upon the relatively mobile organics at these sites, namely chlorinated one- and two-carbon compounds and monoaromatics (benzene and substituted benzenes).

The New Borden plume extends laterally about 150 m from the site and trace organic contaminants extend, rather sporadically, throughout at least 100 m. Concentrations are temporally variable. Individual organics are usually less than 1 ppm in the landfill and less than 100 ppb in the groundwater.

Temporally and spatially variable organic distributions characterize the other plumes as well. Identifying the cause of this variability is the current emphasis at these sites. Variable input of contaminants from the landfill to the groundwater system exerts a major, but not exclusive, control. Detailed coring has been undertaken with the development of a reliable coring method. This permits the detailed hydrostratigraphic/hydrogeologic studies required to evaluate the influence of variations in flow patterns upon the organic distributions. The contributions of variable sorption properties and biodegradation rates to the variability in contaminant distribution are also being evaluated.

In addition, some unexpected biotransformation is suspected within the plume at North Bay. Anaerobic degradation of xylenes and trimethyl benzenes is apparent, for example, and so biotransformation processes are being evaluated with representative laboratory experiments.

THE ACCURATE DETERMINATION OF IN-SITU CONCENTRATIONS OF VOLATILE HYDROCARBONS IN GROUNDWATERS AT THE GLOUCESTER LANDFILL SITE, OTTAWA, ONTARIO

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Key words: Landfill, Leachate, Groundwater, Volatile Hydrocarbons, Gloucester, Contaminant Distribution.

ABSTRACT

The Gloucester Landfill is located near Ottawa, Canada, on a northeast trending ridge of Quaternary age. The ridge comprises a confined aquifer, overlying bedrock, and an unconfined aquifer separated by a silt unit which is an effective aquitard. Two independent Special Waste plumes have previously been identified at the Gloucester Landfill: the southeastern plume, migrating in the confined aquifer, and the northeastern plume, migrating in the unconfined aquifer. The distribution of volatile organic contaminants at the northeastern plume site was examined employing a new sampling technique which used polypropylene syringes as the collection and storage vessels, and a peristaltic pump to bring the leachate to the surface. Laboratory and field evaluations of this method have shown that the syringes are poor storage containers, and losses (≈10%) of some volatiles occur when sampling takes place through a peristaltic pump. Whether these losses are due to interactions with the tubing, or the suction of the pump bears further investigation.

Groundwater velocity measurements taken across the study area varied considerably (< 1 cm/day to 14 cm/day), indicating that the heterogeneities of the surficial sand unit are an important factor in contaminant migration.

Acetate ion was the only identifiable organic acid anion present in the leachate, and is measurable only in areas where the Special Waste contamination is significant. The distribution of volatile organic contaminants and inorganic anions seems to be related principally to the disposal history of the site, and the variable velocity of the groundwater. Sorption interactions are not well described by existing models, possibly because the organic content of the sediment is low (<0.1%).

DESIGN OF GROUNDWATER MONITORING PROGRAMS FOR WASTE LANDFILL SITES

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Key words: Computer Model, Landfill, Groundwater Monitoring, Leachate.

ABSTRACT

A mathematical decision model, incorporating sampling costs, data variability, remedial action costs, and the probability of contamination, has been developed for aiding the design of groundwater monitoring programs. The monitoring program is for detection-type monitoring concerned with observing significant changes in water quality, and where remedial action is initiated upon detection. The tradeoff between periodic monitoring cost and the increased remedial action costs resulting from undetected plume growth is expressed mathematically. The effect on the expected value of the total cost of monitoring and remedial action by decision variables, such as the frequency of monitoring, is investigated.

AN IN-SITU METHOD FOR DETERMINING RATES OF DENITRIFICATION IN GROUNDWATER

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Key words: Denitrification, Groundwater, Nitrates.

ABSTRACT

A survey of nitrate concentrations in unconfined aquifers of Southern Ontario showed that in areas with shallow water tables, nitrate contamination was generally limited to shallow depths below the water table. With the water table at greater depths, nitrates were found to occur at greater depths in the aquifer. The observed distributions have been attributed to the occurrence (or lack of occurrence) of denitrification, and it has been suggested that the extent to which denitrification occurs depends upon the availability of organic carbon.

Previous studies have shown denitrification to be an important process in some aquifers; however, its occurrence is not entirely predictable, and the limiting conditions in the areas where denitrification does not occur are not known. An in-situ method for determining rates of denitrification in groundwater was developed. A column is installed in the field through the centre of hollow-stem augers. Water is withdrawn from the tester, nitrate, chloride and acetylene are added and the solution is re-injected. Chloride acts as a conservative tracer, while acetylene serves as a denitrification block, allowing samples to be analysed for nitrous oxide, to give a positive indication that denitrification is occurring. By determining the rate of nitrate loss, or the rate of increase in N_2O, rates of denitrification can be determined. In addition, nutrients, organic carbon or other additives can be used in the injection water to determine their effect on the denitrification process. The device also appears to have potential for the in-situ study of other biochemical processes such as biodegradation of organic contaminants.

SELECTION OF AERATION DEVICES

J.J. Ganczarczyk

J. Ganczarczyk & Associates

Key words: Aeration Devices, Activated Sludge, Sewage Treatment.

ABSTRACT

Selection of aeration devices for activated sludge treatment plants is usually made on the basis of the equipment costs and the basic technological factors: oxygenation capacity and oxygenation economy (energy consumption) values provided by the manufacturers of these devices. The mixing characteristics and the replacement and maintenance requirements for these devices are taken into consideration less often. Environmental factors such as stripping and cooling abilities, formation of aerosols, and noise generation are only occasionally analyzed. All of these latter factors, in addition to their technological meaning, are related to the health problems of operational personnel at wastewater treatment plants, and of communities in the vicinity of the plants. This study presents a comprehensive and systematic analysis and evaluation of all aspects of aeration devices to facilitate the selection of these devices for specific application. A review of the problems associated with different aeration systems is given and a "checklist" for selection of aeration systems is formulated. The proper selection process of aeration devices for a specific activated sludge treatment facility should be a multi-stage exercise, including (a) client preferences and analysis of the selection restrictions due to local factors and factors arising from the plant design; (b) equipment pre-selection on the basis of energy and capital cost considerations; (c) detailed analysis of technological factors involved in the operation of the aeration devices considered (oxygenation capacity, oxygenation economy and mixing performance); (d) detailed analysis of environmental factors (stripping, aerosol formation, cooling, and noise generation); and (e) final and comprehensive cost analysis of acceptable aeration systems, comprising elements added to correct or improve the technological and/or environmental performance of the devices. Each stage of the selection process will alter the preferences among the available devices and will shorten the list of these devices, but the last stage will bring the final recommendations.

COMPOSITION, MINERALOGY, AND MORPHOLOGICAL NATURE OF INDUSTRIAL WASTES AND THEIR LEACHIBILITY

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Key words: Industrial Waste, Leachibility, Waste Stabilization, X-ray Analysis, Electron Microscopy.

ABSTRACT

The composition and nature of a solid waste must be known in order to predict the leachibility (stabilization) of the waste under a variety of environmental conditions. Whereas the more traditional leach test reveals the mobility of a substance under only the testing conditions, knowledge of the binding of the metal to the solid substrate permits the calculation (and confirmation by testing) of metal mobility under any postulated environment. In addition, knowledge of other solid material may be important to the reactivity of the waste by setting up various chemical buffers, impeding permeation, etc.

This research, in its initial stages, considers the characterization of industrial waste (in order) from its composition, the chemical partial extraction of certain metals, its mineralogy, its morphology, and the specific association of metal to substrate at the micrometer scale. The overall major and minor element composition is obtained by X-ray fluorescence and instrumental Neutron Activation Analyses. In addition, loss on ignition, total sulfur, and organic/inorganic carbon are analyzed. The sequential extraction follows that of Tessier *et al*, and operationally defines the metal concentrations associated with ion exchangeable, carbonate, Fe/Mn oxides, organic, and residual phases. X-ray diffraction analysis is used for major elemental analysis to reconstruct the crystalline compounds. Both Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) are used to morphologically characterize the waste as to size and crystallinity, and to confirm the mineralogy and association of metal and solid. Computer-aided elemental mapping of images with respect to mineralogy further confirms the association of metal and solid substrate. Other follow-up measurements include surface area by the BET technique.

An industrial foundry waste, a plating waste, and a coal waste are used as examples to illustrate the above techniques and the strengths and weaknesses of each procedure. Then some proposals for stabilizing the wastes are developed using the accumulated information on the metal-substrate associations.

MODELLING THE MOVEMENT OF VAPOURS FROM HAZARDOUS LIQUIDS IN SOIL

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Key words: Hazardous Spills, Soil Contamination, Vapours.

ABSTRACT

The discharge of hazardous liquids to soil, either intentionally or by accident, has been the subject of much concern in recent years. Attention has focussed upon tracking the liquid on the surface and through the soil, assessing the impact of the incident on the environment and creating a remedial response.

Since many hazardous liquids are volatile to some degree, concern must exist for the movement of hazardous vapours through soil from the spill or discharge zone. Very little quantitative information has been published about the problem, although reports of volatile contaminants have been reported at some sites. Consequently, work was undertaken to develop a theoretical model to provide a means of exploring the nature of hazardous vapour movement in soil.

The model is based on the Darcy and constitutive equations for intergranular porous media flow. The equations have been solved analytically for simple site situations and numerically with both finite difference and finite element methods for more complex spill and site geometries. Accommodation has been made for realistic venting of the soil surface, variability in soil composition and moisture content, multiple source configurations such as "pancakes" on the zone of saturation and flexibility in the type of liquid under study.

The search for field or experimental data to calibrate and verify the model has not been successful. However, the model has been used to study vapour movement under many possible spill situations through simulation. The impact on vapour transport in soil of liquid type, liquid source configuration, soil condition and ground surface configuration has been studied and reported upon.

POSSIBLE EFFECTS ON GROUNDWATER QUALITY OF THE USE OF LIQUID INDUSTRIAL WASTES FOR DUST CONTROL ON ONTARIO ROADS

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Key words: Groundwater, Liquid Industrial Wastes, Dust Control, Road Oiling, PCB.

ABSTRACT

This study involved a review of the literature and other information concerning dust control practices in Ontario, with a view to evaluating the potential environmental consequences of those practices. Major sources and distributors of dust suppressants were identified and trends in the use of the various materials were indicated. Presently, there are no reported instances of groundwater contamination as a result of dust control practices, though two cases of surface water contamination by PCBs have been attributed to the use of waste oil. An evaluation of the potential for groundwater contamination is presently limited by a lack of detailed chemical data for most of the suppressants used. It is clear, however, that waste oil has the greatest potential for contamination, while salt brine, in some instances, could lead to local contamination of groundwater by inorganic constituents. Though there is no indication that dust control represents a serious threat to groundwater quality, in order to further resolve the questions, site specific investigations would be required.

CODISPOSAL OF INDUSTRIAL AND MUNICIPAL WASTES

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Key words: Industrial Wastes, Municipal Wastes, Waste Disposal, Landfill, Codisposal.

ABSTRACT

The use of municipal landfill sites for disposal of certain industrial wastes is very attractive because of the availability of disposal sites and relatively low disposal costs. The absorption of heavy metals from electroplating sludges by municipal refuse would appear to support the use of codisposal practice. However, the effects of the combination of industrial and municipal wastes on a long-term basis are not well established.

This project was undertaken to investigate the factors affecting the stability of industrial wastes in a simulated municipal landfill environment. Moderately large leach columns under both environmental and controlled conditions have been set up. A discussion will be given of the short-term laboratory leach test results and the long-term leach column experiments.

EFFECTS OF INCREASING AMOUNTS OF NON-POLAR ORGANIC LIQUIDS IN DOMESTIC WASTE LEACHATE ON THE HYDRAULIC CONDUCTIVITY OF CLAY LINERS IN SOUTHERN ONTARIO

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Key words: Non-polar Organics, Organics, Domestic Waste, Leachate, Hydraulic Conductivity, Clay Liners.

ABSTRACT

The hydraulic conductivity, k, of Sarnia soils, mixed with pure liquids varies from 5×10^{-9} to 1×10^{-4} cm/s as the dielectric constant varies form 80 to 2. Permeation of liquids of low dielectric constant (benzene, cyclohexane, xylene) through compacted, water-wet samples ($k \approx 10^{-8}$ cm/s at $e = 1.0$) showed no changes in k, the hydrophobic liquids displacing only 10% of the pore water from microchannels in the clays. Sequential permeation, first by alcohol ($\varepsilon = 30$) followed by a non-polar aromatic yields 10-fold, then 1000-fold, increases in k. The alcohol apparently acts as a mutually soluble association liquid enabling the aromatics to contract the clay double layers.

Current testing of Southern Ontario clays with domestic waste leachates shows little effect on k despite significant retardation and fixation of potassium. Sterilization and bacterial culturing requirements will be discussed.

Results from preliminary testing of clays using domestic waste leachate spiked with known amounts of simple aromatics, with and without alcohol as an association liquid, will be presented, in a first attempt to define threshold concentrations required to initiate detrimental increases in the hydraulic conductivity of clay barriers.

GEOMECHANICAL INVESTICATION OF NEAR-SURFACE FRACTURES IN CLAY TILLS

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Key words: Clay Till, Nanticoke, Southern Ontario, Waste Disposal, Disposal Sites, Leachate, Near-surface Fractures, Contaminant Migration.

ABSTRACT

The purpose of this investigation is to characterize the nature and variability of near-surface fractures in clay tills of Southern Ontario. To accomplish this, four research sites have been chosen to provide a regional as well as geomorphological variation to the clay soils. These sites are located in the following: Haldimand clay plain at Nanticoke, Essex clay plain near Essex, Lambton clay plain near Sarnia and Port Stanley till near London.

The field work component of this research involves digging trenches with a backhoe down to depths of 13 feet to permit fracture mapping and block sampling, as well as auger drilling and Shelby tube sampling down to a maximum depth of 50 feet. The sampling tubes used have an inside diameter of 4.5 inches.

The laboratory component of this research involves various strength and deformability tests using a triaxial cell and mineralogical analysis using x-ray diffraction. The triaxial tests will determine shear strengths and stress-strain relationships of the clays in triaxial compression and extension. A hydraulic fracturing method will also help determine the tensile strength of the fractured clays in the triaxial cell.

Comparing fracture orientation data, mineralogical analysis results and geotechnical properties of the clay soils, a good indication of the regional variability and behaviour of near-surface fractures in Southern Ontario clays shall be provided.

The results of this investigation will be directly applicable in assessing the suitability of siting waste disposal facilities in surface clay deposits. The behaviour of near-surface fractures during construction and their possible role in future contaminant migration from waste impoundments shall be better understood.

WASTE MANAGEMENT PLANNING FOR THE PHARMACEUTICAL INDUSTRY

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Key words: Waste Management, Pharmaceutical Waste, Waste Disposal.

ABSTRACT

Information obtained on the subject study will be thoroughly reviewed. A questionnaire will be prepared and sent to all pharmaceutical manufacturers in Ontario.

The questionnaire will be based on the types of drugs produced, processes used, chemical or raw materials used, solid and liquid waste produced. There will be questions on the type of wastes (for classification purposes), quantities produced and present methods of disposal (e.g. treatment facility, handlers, disposal companies). There will also be questions concerning the hazardous nature of wastes, chemical analysis, inventory labelling, storage, etc.

Once the questionnaires are mailed, personal interviews will be arranged with the companies who do not respond within a definite time, to obtain first-hand information (and perhaps to explain the questionnaire if not properly understood, its purpose, etc.).

During 1984-85, the main thrust will be to obtain maximum information through interviews and the questionnaire, to establish a data base, inventory requirements and approaches, and also to document regulatory policies and requirements pertaining to the industry.

REFUSE PYROLYSIS EMISSIONS TESTING

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Key words: Refuse, Municipal Solid Waste, Pyrolysis, Emission Rate, Incineration, Hazardous Contaminants, Hazard Assessment.

ABSTRACT

EFW Systems Incorporated has built and is currently evaluating the performance of a 1 tonne/h municipal solid waste (MSW) pyrolysis unit. The feed to the unit consists essentially of shredded MSW combustibles. Low energy gas product will be combusted and used both to sustain pyrolysis and to produce about 350 Kw of electricity.

The Ministry of Energy requested the Ontario Research Foundation to evaluate the performance of the pyrolysis unit, primarily by determining the composition of the gaseous product and by determinig the emission rates of contaminants in the product. Contaminants included in the evaluation were:

- particulate matter
- acid gases
- gases
- dioxins and furans
- PCBs, chlorobenzenes and chlorophenols
- polycyclic aromatic hydrocarbons
- trace metals

The purpose in measuring these emission rates was to identify any potential environmental hazards associated with generation and use of the pyrolyser gases. This included confirming the emission rates of the above contaminants with current environmental standards and developing contaminant emission factors.

APPROACHES TO MINIMIZING SOLVENT EFFECTS IN MUTAGENICITY ASSAYS

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Key words: Mutagenicity, Organic Solvent, Analytical Methods.

ABSTRACT

Testing of potentially hazardous chemicals usually requires that they be dissolved in a suitable solvent prior to administration. In many cases the chemicals are hydrophobic, necessitating the use of organic solvents. Unfortunately, in recent years it has become clear that many organic solvents interfere with or modify the response of an assay. Such solvent effects may include high solvent toxicity, the introduction of solvent derived mutagens or alteration of an assay response to known mutagens. In each case, the data obtained are equivocal and of questionable utility. Even the use of such popular solvents as DMSO has proven unsatisfactory in some assay systems.

Minimising solvent effects is emerging as a major problem in mutagenicity testing. Our approach to the problem has involved testing a variety of natural and artificial oils as potential solvents. Natural plant oils, e.g. corn, olive and sunflower, have low toxicity and suitable solubility characteristics; however, we have found that there remain problems with their use. These problems derive from the aging of such oils and their variable composition, in particular the variable amounts of minor constituents such as tocopherols which have been shown to interfere with the expression of mutagenicity in several assay systems. The use of pharmaceutical grades of plant oils does not eliminate the problems since pharmaceutical standards allow the inclusion of modest and variable amounts of the troublesome ingredients. Clearly, if natural oils are to be used internationally, more restrictive standards for their composition and use will be required. An alternative approach is the use of synthetic oils which include none of the presumed deleterious ingredients. In this case, the solvent composition can be adjusted to provide the best compromise between different chemical and physical characteristics. For example, the degree of saturation of triglyceride substituted fatty acids affects the viscosity, solvent capability and susceptibility to oxidation of triglycerides. We will demonstrate the use of such solvents in a widely used *in vivo* assay system.

LEACHING STUDIES OF PCDD AND PCDF FROM MUNICIPAL INCINERATOR FLYASH

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Key words: Leachate, Dioxins, Furans, Flyash, Water Quality, Municipal Incinerators, Analysis.

ABSTRACT

This study concerns the possibility of polychlorodibenzo-p-dioxins (PCDD) and polychlorodibenzofurans (PCDF) entering the environment through the leaching of municipal incinerator flyash into water. The study also takes into account the effect of the pH of water on the extent of leaching.

Several methods for simulating the actual conditions by which flyash comes into contact with water were investigated. A Soxhlet extraction of flyash with water was finally chosen for this leaching study because of its simulation of the circulation of water in nature and because of its high extraction efficiency. Following the extraction, a simple benzene-water partitioning step was used to transfer the organic compounds in the water extracts into organic solvent for a subsequent GC and GC/MS analysis. Good recovery of PCDD at the 2 ppt level was obtained using benzene partitioning.

The analytical results for water extracts at pH levels of 4, 7, and 10 show clearly that PCDD and PCDF enter water through leaching. These compounds were found in water at the 1 to 400 ppt level. Because of these low concentration levels, the reproducibility and accuracy of quantitative results were poor.

The study was extended to identification of other organic compounds that were also leached from the flyash into the water extracts. Identification of these organic compounds was accomplished using the techniques of GC/FID, GC/EIMS, GC/PICIMS and GC/NICIMS. These compounds were present at higher concentrations than the PCDD and PCDF and many were chlorinated and toxic. At pH 4, a total of 71 compounds were found; at pH 7, 64 were found, and at pH 10, 56.

LABORATORY STUDY OF TILE DRAIN EFFICIENCIES FOR LEACHATE COLLECTION

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Key words: Tile Drainage, Leachate, Leachate Collection, Hydraulic Characteristics.

ABSTRACT

A physical 2-dimensional model using a homogeneous and isotropic sand medium, with water as the fluid, was tested to determine the effectiveness of tile drain systems in capturing groundwater recharge from infiltrated precipitation. For a landfill, this recharge is leachate. Experiments were conducted for configurations with varying hydraulic gradients, position of the tile within the flow field, thickness of the flow field, tile spacing and recharge rate. All experiments were for the steady state condition.

Original gradients were established by varying both the recharge rate at the upper surface and the hydraulic head in a permeable "aquifer" that formed the lower boundary of the model.

The ratio of flow that bypassed the tile drain(s) to the total recharge (input) to the system (Q_A/Q_R) is a measure of the efficiency of the tile system for leachate collection.

Graphs of Q_A/Q_R vs R/K_s (recharge/saturated hydraulic conductivity) for different positions of the tile drain(s) and spacing of tile drain(s) (H_D/L), show that unless the tile is placed at an elevation below the hydraulic head in the aquifer, some water (leachate) will bypass the collection system.

In our model studies, the water table is a consequence of the parameters of the medium and the experimental conditions but the position of the water table is not a factor in evaluating the performance of the tile drain(s).

DEVELOPMENT OF DESIGN CRITERIA FOR OPTIMAL RECOVERY OF LEACHATE UNDER SANITARY LANDFILLS

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Key words: Leachate, Leachate Recovery, Sanitary Landfills, Landfill Design.

ABSTRACT

This study proposes a numerical approach to evaluate the efficiency of leachate collection systems under landfills. It applies a finite element model to a 2-D steady-state flow system of variable hydraulic parameters and spatial dimensions.

Results for homogeneous, isotropic media show that most leachate can be collected if an upward gradient exists between the drain level and the bottom of the system. If the gradient is downward, the drains have to be closely spaced in order to collect the leachate. Drain performance depends also on the rate of recharge to the system which controls, in part, the height of the groundwater mound between tiles. Optimum recovery is attained when all leachate is collected with minimum infiltration from regional aquifer water. Further results show that natural and artificial anisotropy or layering in the porous medium can increase significantly the performance of a given design. Consequently, the presence of such characteristics can be a determining factor in the creation of efficient leachate recovery systems.

LISTOWEL ARTIFICIAL MARSH PROJECT

W. Lewandowski, Ministry of the Environment

Key words: Listowel, Sewage Treatment, Effluent, Marsh Treatment Systems.

ABSTRACT

A study was conducted to investigate the efficiency and feasibility of year-round marshland wastewater treatment and to provide guidelines for the design and operation of these systems in Ontario. In addition, the study examined the role of various marsh components in wastewater renovation and the fate of wastewater constituents.

An experimental facility was constructed adjacent to the existing sewage works in the Town of Listowel (which consists of a complex-mix aeration cell and two lagoons linked in series) and was operated for four years (1980-84). The pilot project consisted of five separate experimental marsh treatment systems which together treated 4% of the town's sewage (1.2 MIGD). Several marsh system designs and types of pre-treatment were tested. Operation of the marsh systems allowed flexibility in hydraulic loading rates, water depths and detention times.

Cattail plants (Typha spp.) produced a high biomass under flooded conditions. Nutrient removal by harvesting, however, was not considered to be cost-effective. The channelized marsh configuration demonstrated the highest treatment efficiencies. Hydraulic retention time in the marshes was effectively regulated by adjustments of water depth to compensate for seasonal influences. Treatment efficiency declined when the hydraulic detention time in the marshes deviated from the range of 7 - 14 days.

Marsh effluent quality was at levels between secondary and tertiary treatment. The four-year annual average effluent quality in the channelized marshes in terms of BOD, SS, TP and TKN was 7.6, 9.2, 0.5 and 6.2 mg/L, respectively, in the system receiving lagoon-treated effluent, and 9.6, 8.0. 0.6 and 8.7 mg/L, respectively, in the system receiving aerated cell effluent.

Elevated ammonia, hydrogen sulphide and phenol levels in the marsh effluent in summer and/or winter months were attributed primarily to anaerobic conditions. Low temperatures also appeared to be a factor in increases in effluent ammonia levels in winter. Oxygen deficits and high phosphorus loadings may have contributed to the decline in annual soluble phosphorus retention observed during the study. Large reductions in fecal bacteria were achieved, although in some months levels exceeded Ministry objectives for disinfected effluent.

The report describes the recommended pre-treatment unit for marsh sewage treatment systems based on the experience gained at Listowel. This process ensures low influent levels of solids and phosphorus, as well as consistently high dissolved oxygen concentrations, and has been incorporated into the design of the full-scale marsh treatment facility at Port Perry, Ontario. The treatment capabilities of the Port Perry facility will determine the potential for the application of marsh wastewater treatment in Ontario.

EFFECTS OF METALS FROM MINE TAILINGS ON THE MICROFLORA OF A MARSH TREATMENT SYSTEM

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Key words: Mine Tailings, Metals, Wastewater Treatment, Marsh Treatment Systems, Bacteria, Listowel.

ABSTRACT

The artificial marsh treatment system is a viable method of wastewater treatment in small communities. Although several marsh facilities have been constructed in Ontario, the marsh located in Cobalt is unique because it is constructed on a mine tailings basin. The purpose of this study was to determine if elution of metals from mine tailings would have an adverse effect on the microflora of a marsh treatment system.

Samples of surface water were collected from a marsh at Listowel, as well as from the Cobalt marsh, and the heterotrophic bacteria identified. The micro-organisms in both marsh systems were found to be similar; Acinetobacter and Flavobacterium were the predominant genera.

Both artificial marsh systems were able to effectively reduce concentrations of Escherichia coli, Pseudomonas aeruginosa, total coliforms, fecal coliforms, and fecal streptococci. For example, E. coli counts of 4.7×10^5 per 100 mL at the Cobalt sewage entrance site were reduced to less than 100 per 100 mL after marsh treatment.

Sediment sampling results indicated that the Cobalt and Listowel systems supported similar numbers of autotrophic bacteria: denitrifiers, sulphate reducers, sulphate oxidizers, Nitrosomonas and Nitrobacter spp.

When the bacterial isolates were subjected to a battery of metal solutions using the intracellular ATP assay, the resazurin reduction assay, and the agar plate toxicity test, the Cobalt marsh isolates were found to be more metal resistant than the Listowel organisms. Furthermore, it was noted that the Cobalt bacteria possessed multiple metal and antibiotic resistance. An antibiotic resistant Klebsiella sp. isolated from the Cobalt marsh was shown to contain four plasmids.

Of the 11 metals tested, arsenate was the least toxic and mercury the most toxic. All isolates were susceptible to much lower concentrations of metals when mixtures of metals were used. The intracellular ATP bioassay was deemed to be the most sensitive method of assessing toxicity of the metals.

CHEESE WHEY TREATED BY THE KENOX(R) PROCESS

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Key words: Cheese Whey, Industrial Waste, Wet Air Oxidation, Energy From Waste, Waste Treatment

ABSTRACT

A study was carried out by Stone & Webster Canada Limited to assess the technical integrity of the Kenox(R) Process and to ascertain any economic or technical advantages offered by this process for the treatment of cheese whey wastes.

The Kenox(R) Process is a wet air oxidation process, which employs a unique design to obtain the necessary degree of mixing between waste stream and air (as the oxidant) at elevated temperatures and pressures.

Experiments were carried out on a prototype installation situated at a Downsview, Ontario cheese manufacturing plant.

This assessment indicated that a reduction of 67% of the biochemical oxidizable matter in cheese whey, as measured by "Biochemical Oxygen Demand" (BOD_5), for a single pass operation (12 minutes reactor residence time), and a 92% BOD_5 reduction for a "total recycle" operation (48 minutes reactor residence time) is achievable with the Kenox(R) System. The heat exchanger system was not suitable for cheese whey due to excess fouling problems which caused extensive delays and operating time losses. An auxiliary treatment system would be required to bring the BOD_5 and suspended solids (S.S.) content of the effluent from the Kenox(R) System to limits set by Metro Toronto's By-law 148-83 (BOD_5 = 500 mg/L, S.S. = 600 mg/L).

Usable heat, in the form of hot water at 140°F, was recovered from the process at a rate of approximately 770,000 Btu/day, when the unit was operating at a feed rate of 1 USgpm cheese whey.

In its present state of development, the Kenox(R) System does not appear to present an economic advantage to the Downsview Cheese Manufacturing Plant because of the unique problems encountered in dealing with cheese whey. However, it clearly has a viable future in the treatment of waste streams and could become attractive in a wide variety of situations.

CHEESE WHEY CONCENTRATION BY REVERSE OSMOSIS

Zenon Environmental Inc.

Key words: Resource Recovery, Cheese Whey, Reverse Osmosis.

ABSTRACT

The Riverside Cheese and Butter Company in Trenton has purchased a reverse osmosis system to be used to concentrate cheese whey so that it can be fed to beef cattle and produce a permeate that will be acceptable for discharge into the sewer. In this way, an environmental problem will be solved while recovering a valuable by-product.

As an environmental engineering firm and manufacturer of reverse osmosis equipment, ZENON Environmental Inc. has been asked to evaluate the reverse osmosis system installed at Riverside. Over the next few months, work will be carried out to determine the techno-economic feasibility of this approach, in addition to assessing the environmental benefits. The final report will include the evaluation, and also provide basic information for others in the Dairy Industry who wish to take advantage of this very promising technology.

FATE OF HAZARDOUS ORGANIC COMPOUNDS IN MUNICIPAL WATER POLLUTION CONTROL PLANTS

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Key words: Contaminant Fate, Fugacity, Hazardous Organics, Sewage Treatment.

ABSTRACT

Many of the toxic organics which threaten our environment find their way into municipal water pollution control plants. It is therefore important to know the fate of these organics; specifically, how much will be stripped, adsorbed, bio-oxidized or chemically converted in our treatment systems. The objective of this three-year study is to monitor several toxic organic contaminants in order to be able to predict quantitatively how much of each chemical would be removed by a biological system.

A Level II fugacity-based Predictive Fate Model (PFM) was developed in order to describe the behaviour of organic pollutants. Under steady state conditions, the PFM could predict the concentration of an organic contaminant in the air, water and sludge compartments of a municipal plant based only on the physical properties of the chemical (vapour pressure, solubility, octanol-water partition coefficient, molecular weight and the biodegradation rate) and on the operating parameters of the biological treatment plant (flow rate, chemical concentration, MLSS, sludge return and wasting rates).

To date, after one year of investigation, the PFM has been developed and data on the volatilization rate of four compounds (toluene, napthalene, chlorobenzene and pentachlorophenol) in a continuous flow, laboratory scale, completely mixed activated sludge reactor have been collected. Studies on the adsorption and biodegradation of these same organic chemicals in simulated wastewater will continue through the second year and the data will be tested in the fugacity-based model.

In the final stage of the three-year program, the model will be used to predict the fate of various organic compounds in larger scale units treating municipal wastewater.

EXTRACTION & CONCENTRATION METHOD FOR TESTING OF LANDFILL LEACHATES

G. Thomas, Ontario Research Foundation

Key words: Landfill, Leachate, Mutagenicity Testing.

ABSTRACT

A major problem in this project has been associated with the selection of a suitable "site" for experimental studies. It was felt necessary to have a "site" selected so that chemical validation studies could be performed on a solid matrix material concurrently with validation studies associated with groundwater.

Thus, work on this program has not progressed as anticipated and the corresponding costs have been minimal. It does appear that a solution to the "site" problem is imminent.

GRIT REMOVAL AT SEWAGE TREATMENT PLANTS USING A LOW PRESSURE HYDROCYCLONE

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Key words: Grit Removal, Sewage Treatment, Hydrocyclone, Toxic Contaminants.

ABSTRACT

The objective of the project is to develop a design of hydrocyclone which will efficiently remove grit from sewage entering treatment plants at minimal cost. This should eliminate problems in the plant from deposits of grit in lines and in digesters, as well as reducing abrasive wear on equipment. The same hydrocyclone design may also prove useful in water treatment plants in a system where granulated active carbon may be used to remove toxic chemicals.

The operation of a hydrocyclone at low pressure differential is possible due to a novel design in which the velocity energy of fluid leaving the unit is recovered, thus creating a vacuum at the core of the vortex in the device.

DEVELOPMENT AND VALIDATION OF PROTOCOLS FOR SAMPLING SURFACE AND GROUNDWATERS FOR ORGANIC CONTAMINANTS

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Key words: Water Quality, Groundwater, Volatile Organics, Water Sampling.

ABSTRACT

In the first phase of this research, present methods of sampling waters, especially groundwaters, for subsequent analysis of volatile organic contaminants were evaluated. The major sources of bias included well flushing procedures, sorption onto sampling equipment and volatilization due to exposure of samples to the atmosphere during sampling.

Following a review of the literature, a series of laboratory experiments were conducted which evaluated the bias and variability of results when groundwaters are sampled by various techniques. The performance of a suction lift system (peristaltic pump) and a gas-drive system (triple-tube sampler) were evaluated. Both systems introduced some negative bias (0.8 to 21.6%) but little variability with standard deviation of less than 10% of the mean. Surprisingly, the suction lift system induced less volatile-loss than the positive-pressure gas-drive system.

It is concluded that monitoring programs should be as standardized as possible. Requirements for well flushing, in particular, may be difficult to establish a priori. For volatile organics, the major source of bias appears to be volatilization loss and so a sampling system which eliminates this loss will be investigated in phase two of this research.

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